Sustainable African Agricultural Technology Systems

Project Design Team Report

Project No. 698–0478

Submitted to
The African Bureau, Office of Sustainable Development,
Productive Sector Growth and Environment Division of the
United States Agency for International Development
under contract no. LAG–4200–I–00–3056–00, DO 8 and 9

Submitted by
Tropical Research and Development
7001 S.W. 24 Avenue
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February 1995

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Acronyms

AFTEN	The World Bank, Africa Region, Technical Department, Environment Division
ARTS	Office for Analytical Resources and Technical Support (USAID/AFR)
ASARECA	Association for Strengthening Agricultural Research in East and Central Africa
CIDA	Canadian International Development Agency
CILSS	Comite Inter-etats de la Lutte contre le Secheresse dans le Sahel
CST	commodity-sector technology
DJIA	Dow-Jones Industrial Average
ESA	East and Southern Africa
FARA	Food and Agricultural Resource Analysis Division (USAID/AFR/ARTS)
FFA	framework for action
GDP	gross domestic product
IARC	international agricultural research center
IDRC	International Development Research Centre (CIDA)
IPR	intellectual property right
IRRI	International Rice Research Institute
NARI	National agricultural research institute
NARS	National agricultural research system
NGO	Nongovernmental organization
NRM	Natural resources management
NRMS	Natural Resources Management Support project (USAID Project)
OTR	Office for Technical Resources (USAID/AFR)
PARTS	Policy, Analysis, Research and Technical Support (USAID/AFR project)
PSGE	Productive Sector, Growth and Environment Division (USAID/SD)
REDSO	Regional Development Support Organization (USAID)
SAARFA	Strengthening African Agricultural Research and Faculties of Agriculture project (USAID Project)
SAATS	Sustainable African Agricultural Technology Systems (PARTS Project Amendment)
SACCAR	Southern African Center for Coordination of Agricultural Research and Training
SAFGRAD	Semi-Arid Food Grains Research and Development (USAID Initiative)
SD	Office of Sustainable Development (USAID/AFR)
SPAAR	Special Program for African Agricultural Research
SSA	Sub-Saharan Africa
SSPA	Social Science and Policy Analysis
TAC	Technical Advisory Committee
TDD	Technology development and diffusion
TDT	Technology Development and Transfer (USAID/AFR/SD/PSGE Unit)
TOR	terms of reference
USAID	United States Agency for International Development
WCA	West and Central Africa

Executive Summary

Much of African agriculture is in a low-level equilibrium trap. Levels of production and factor production and factor productivity, except for capital, are usually low. But in spite of low levels of technology and generally unfavorable farm gate prices, farmers optimize output. These farmers, in large part women, allocate their poor land, untrained labor, and meager capital (primarily crude implements) in a manner that is surprisingly efficient—but that leads to a dead end. These allocations preclude not only income gains for the farmers; they also prevent agriculture from making its potential contribution to overall economic development. A breakout from the equilibrium trap will require understandable, usable technology that will increase yields and reduce costs.

Such a breakout is possible only if the effects of yield-increasing technology are carried through to the ultimate consumer. If stopped short, so that surpluses become price depressors at the farm gate rather than increased sales and profits in the market, the economic development potential is lost. And on a larger scale, increased output offering dependable supplies to processing industries will become an engine of development. What is needed throughout the production-marketing system is output-enhancing technology. But the production must be sustainable, not degrade the environment, and profitable throughout the system. These are the underlying precepts of this project.

The Sustainable African Agricultural Technology Systems (SAATS) initiative is a Policy, Analysis, Research and Technical Support (PARTS) project amendment. PARTS to date has given most of its attention to on-farm production, productivity, and profitability. The mission of SAATS is agricultural transformation. SAATS will support African organizations, which will identify commodity and industry problems and opportunities, lay out courses of action to solve problems from the farmer's field to the marketed product, and develop and apply technologies offering rapid results. SAATS will "pick the low apples first," identifying priority industries and planning and executing research that aims at transforming, first, those industries and, later, agriculture itself.

The SAATS Initiative builds upon lessons learned from previous activities and impact assessments. USAID's support for African agricultural technology development and transfer (TDT) declined from $55 million in 1986 to $35 million in 1991; real (inflation-adjusted) levels saw a larger decline. The decision to reduce support was based largely on statistics tangential to the effectiveness of agricultural technology development and transfer, not upon investigations of agricultural technology development and transfer outputs and the impacts thereof. The primary indicator of the efficiency of agricultural technology development and transfer in generating social impact is the rate of return (ROR). Prior to 1990, there were only three published rates of return to African agricultural technology development and transfer. Following impact-assessment activities commissioned by USAID and others, at least fifteen studies are now available. Each of these studies finds that agricultural technology development and transfer has had impact.

Eleven of the fifteen studies indicate that the benefits arising from agricultural technology development and transfer are sufficiently large to justify the investments. The highest rates of return in Africa are comparable to the highest rates of return found in other parts of the developing world. For example, the 135 percent rate of return to the introduction of maize into the Mali Textile Development Company zone in Mali exceeds the 133 percent rate of return to Indonesian rice, the highest published rate found to investments in Asian agricultural technology development and transfer.

The rates of return studies do not deny the severe problems currently existing within national agricultural research systems and other components of African agricultural technology development and transfer systems. What they show is that important accomplishments have been made despite these problems. Three implications for the management of African agricultural technology systems emerge:

1. maintain current, real, funding levels for agricultural technology development and transfer for the immediate future;
2. concurrently, undertake institutional reform; and
3. in the medium term (two to five years), increase real levels of funding as agricultural technology development and transfer institutions complete the critical steps in the reform process, become viable organizations to support agricultural technology development and transfer, and have the capacity to manage and spend additional funds.

SAATS responds to these lessons as a demand-driven initiative of analysis and action for African agricultural research. SAATS targets USAID's priority area of economic growth. Without a viable and growing agricultural sector, sub-Saharan Africa (SSA) will not experience economic growth. The design explicitly incorporates USAID's priority of environment through linkages with natural resources management; the priority of democracy and governance is incorporated through empowerment of Africans. SAATS is complementary to and supportive of the priority areas of population and disaster mitigation through increasing the availability of nutritionally adequate food at affordable prices.

The SAATS mission is to achieve sustainable increases in productivity that accelerate economic growth through agricultural transformation. SAATS will support African organizations to identify commodity and industry problems and opportunities, lay out courses of action to solve problems ranging from farm production to the marketed product, and aim for adoption and rapid impact of technologies. SAATS follows the old adage, "pick the low apples first," identifying priority industries and planning and executing research that aims to transform, first, those industries and, later, agriculture itself. This last transformation leads in turn to readily discernible economic development, e.g., employment generation, expanded trade, and participation in the global economy. The SAATS strategic objective is increased and sustained productivity of priority agricultural and natural-resource system products. The strategic objective will be achieved by sustainable, agricultural intensification through on-farm and off-farm technical innovation.

In support of this strategic objective, SAATS strives for four program outcomes:

1. Increased use of sustainable and profitable techniques.
2. Increased availability of and access to profitable and sustainable technology.
3. Strengthened human and institutional capacity for agricultural and natural-resource technology systems.
4. Policy and market environment allowing for agricultural transformation in priority subsectors.

The first outcome is the direct cause of the strategic objective: intensification occurs if and only if there is increased use of technical innovations. The remaining three objectives support the first.

Increased productivity and increased use of sustainable and profitable techniques are directly dependent on availability of and access to those techniques. Availability means that the techniques are known to the technology system and implementable within the social and economic constraints of the region or country. Access means that farmers, processors, retailers, and other users have the opportunity to purchase the input that embodies the technique and to acquire the knowledge to implement the improvement. Lack of either availability or access means a failure to generate the rapid technical change needed to achieve the strategic objective.

Strengthened human and institutional capacity is needed at both the regional and national levels. As agriculture intensifies, continued research, development, and transfer of new and increasingly innovative techniques and products are required. Current African technology systems are not capable of sustainable development and dissemination of profitable innovations continually, sustainably, and rapidly.

Policy and market environments that allow for productivity increases in agriculture and for the translation of these increases into meaningful benefits for the nonagricultural sector are necessary conditions for increasing agricultural productivity and stimulating agricultural transformation and economic growth. Increased use of profitable and sustainable techniques is necessary but not sufficient because improved on-farm productivity does not lead to greater access of consumers in urban and food-deficient rural areas to more affordable food when the policy and market environments fail to bring food to the needy location. While structural adjustment has made substantial progress in eliminating government interventions that were inefficient or worse, it has not replaced them with the legal and structural underpinnings necessary to facilitate a competitive market in technological outputs.

The critical, path-breaking component of the SAATS program strategy is to balance on-farm and off-farm innovation and the explicit consideration of consumer needs and wants. While maintaining support for traditional, on-farm production innovations, SAATS will also target research, development, and transfer of off-farm innovations that increase productivity and profits or employment of postharvest manufacturing and service

firms and disseminate innovative techniques for preserving natural resources.

SAATS will support African regional and national institutions to balance on-farm and off-farm activities by

- working regionally to support national development
- integrating agriculture and natural resources management
- empowering Africans to determine and manage the technology development and transfer agenda
- building donor coordination and coalition around the African agenda
- leveraging funds
- initiating a demand-driven approach to research planning and execution
- providing increasing attention to consumer interests, including off-farm technological needs.

Working regionally to support national development has two thrusts: to assist national agricultural research systems with institutional reforms that will achieve the more effective technology systems, and to coordinate the areas of technical investigation that are most cost-effective when carried out at the regional level. An effective regional program is one that captures regional synergies while remaining cognizant of the primacy of national systems and their participants. Thus, SAATS will facilitate the use of umbrella organizations, consisting of representatives from national systems, as regional mechanisms for coordinating the actions of national systems. In addition, working across national systems that have limited capacities allows building of the critical masses of scientists and knowledge that are necessary to achieve impact.

Integrating natural resources and agricultural management is essential to the functioning of any agricultural technology system. The current level of antagonism between agriculture and natural resource management (NRM) is so unhealthy as to threaten both agriculture and the natural resources upon which it depends. "The productivity and well-being of Africa's agrarian and pastoral peoples is directly linked to the wise use and conservation of the natural resource base. ... only the farmers and herders—planting trees, controlling erosion, nurturing soil and water resources, managing woodlands and rangelands with a view to direct economic benefits for their families—can begin to make the substantial impact required to reverse the decline and realize the full potential of the natural resource base (AFR/OTR, pp. 1–2). The SAATS approach combines agricultural and natural resource concerns for providing farmers and herders with technical innovations that are both profitable and sustainable. It supports institutional reform to generate such innovations.

SAATS will empower Africans to determine and manage the technology agenda through institutional and technical support to invigorate African priority-setting processes, and by providing funds for agricultural technology development and transfer in the resulting priority areas. Concurrently, Africans must grapple with and conquer the challenges of providing sound leadership and management of African institutions; of determining priorities based on sound economic, technical, and social analysis; of making

African technology systems responsive to the needs of the people and consistent with democratic principles; and of generating domestic political and financial support for their agenda.

Three fundamental tools will be employed to build donor coordination and coalition around the SAATS approach and the resulting, African, research agendas: institutional reform at the regional and national levels to support financial accountability and to improve the cost-effectiveness of research, development, and delivery; transparent determination of analytically sound technological priorities to stimulate economic growth; and institution of financially sustainable funding mechanisms.

SAATS will leverage funds in two ways: by identifying needed actions at the regional level; and by working with national agricultural research systems and donors, particularly but not exclusively USAIDs, to obtain funding, technical assistance, and nonproject assistance necessary to implement the appropriate national reforms. By leveraging funds in these manners, a regional approach holds the greatest promise for coordinating donor and national actions in the region. It is also the best hope for restoring and eventually increasing the level of agricultural technology development and transfer funding that prevailed in the early and mid 1980s.

The SAATS Initiative supports a demand-driven approach to technical change through (1) better links among public-sector organizations, such as research and extension services and universities; (2) better links with corporations, nongovernmental organizations, and other private-sector participants; (3) explicit consideration of clientele groups as equal partners in determining technological needs; (4) explicit consideration of the socioeconomic and political environments in determining priority areas for research and development; and (5) co-stewardship of research-service outputs with their users. The decisive institutional innovation is the sharing of stewardship responsibilities with the demanders of the technological innovations.

Increased attention to consumer interests is warranted because examinations of agricultural innovations and its impacts show that consumers are the major beneficiaries, and because innovations directed toward helping consumers help many of the poorest of the poor in sub-Saharan Africa. Such direction is also a critical component of stimulating agricultural transformation. The most noticeable impact of the increased attention to consumer interest will be a better balance of research resources between on-farm and off-farm activities. Explicit recognition will be given to the role of technical innovation in providing rural and urban consumers with market access to nutritionally adequate food supplies at affordable prices.

SAATS will undertake three types of actions: nonproject assistance; the strengthening of regional and national technology institutions; and support for technical research, development and dissemination. Nonproject assistance will focus on developing sustainable funding mechanisms, leveraging funds, and activities best carried out in a supraregional context such as support for the Special Program for African Agricultural

Research. Institutional support will strengthen and empower African mechanisms that rationalize and harmonizing agricultural technology development and transfer activities, help build coalitions for support of agricultural technology development and transfer institutions and activities, build human and institutional capacity to respond to evolving client needs, help create regional postharvest working groups, help create regional national resource management working groups, and create and strengthen regional social science and policy analysis networks. Technical support will be provided to the areas determined to be priorities by a transparent and technically sound process carried out by African national and regional organizations. These areas may include research, development, testing and screening, and transfer. Assistance may be channeled to public or private-sector individuals or firms who excel in the expertise needed.

Targets for program outcome 1 include (1) that SAATS generate, disseminate, or transfer improved techniques in priority subsectors that cover at least one third of agricultural GDP in each region; (2) to bring multiple new techniques into use in the same productive activity (e.g., hybrid seeds and mechanization); and (3) to provide innovations alleviating the one or two primary off-farm constraints (or capitalizing on opportunities) in the priority subsectors. These techniques should lead to a cost reduction of at least ten percent per year for three years, among adopters (or thirty percent in a single year).

Targets for program outcome 2 will depend on the priority areas chosen, but should be commensurate with the targets for program outcome 1. For example, the improved techniques covering 1/3 of agricultural GDP should be available in stores, retail markets, or other outlets visited at least once a year by 80 percent of the target population. The real price of improvements embodied in purchased inputs, such as hybrid seeds, shall have declined. At the end of the project, potential innovations covering another 1/3 of agricultural GDP should be in the screening and testing stage, with projected daters of release within five years of the end-of-project.

The key targets to be achieved under program outcome 3 are legal incorporation and certification to receive funds by regional and national organizations; adequate representation of national interests in the regional organization; adequate representation of private-sector interest in the organization; endorsement by the organization of guidelines for information to be used in cross-commodity and within-commodity priority setting for technical and programmatic activities, based on economic, social and technical analysis; endorsement of protocols for actually making the priority-setting decisions; endorsement of similar information and protocols by national agricultural research institutes; endorsement of regional protocols for determining which regional training, technical assistance, and other activities for strengthening national institutions are to be supported, and to what extent; implementation of monitoring and evaluation procedures; implementation of accounting procedures for financial management; and implementation of procedures supporting eventual impact assessment. Specific targets for program outcome 4 are not available until analysis of particular constraints is completed. General targets include policy and market-constraint analysis, specification of policy modifications, and implementation of the modified policies.

1. Introduction and justification

1.1. SAATS mission statement

The Sustainable African Agricultural Technology Systems (SAATS) Initiative is a demand-driven initiative of analysis and action for African agricultural research. Its goal is to achieve sustainable increases in productivity and accelerate agricultural transformation. SAATS will support African organizations to identify commodity and industry problems and opportunities, lay out courses of action to solve problems from the farm to the marketed product, and aim for rapid introduction of high-impact technologies. SAATS follows the old adage, "pick the low apples first," identifying priority industries and planning and executing research that aims at transformation, first, of those industries and, later, of agriculture itself, leading to readily discernible economic development: employment generation, expanded trade, and participation in the global economy.

SAATS will vitalize agriculture by:

- Working regionally to support national development.
- Integrating agriculture and natural resources management.
- Increasing the role of African leaders in determining and managing the technology development and transfer agenda.
- Building donor coordination and coalition around the African agenda.
- Leveraging funds.
- Initiating a demand-driven agenda.
- Providing increasing attention to consumer interests, including off-farm technological needs.

Box 1. SAATS concepts

The SAATS mission statement relies on a few principal ideas. *Increased productivity* means that technical progress is utilized to generate greater output from existing levels of input. *Sustained* means that the technical progress and the technology development and transfer process generating and diffusing the technical progress do not degrade the natural resource base but do preserve adequate political support for the technology system (by empowering user groups and other agents in the agriculture and natural resources system), and maintain the financial sustainability of the technology system (so that continued progress and technical change are possible). *Agricultural transformation* is the process of moving from subsistence agriculture to a modernized system based on improved techniques and information, specialization, and market transactions. The phrase *agricultural and natural resources system* refers to the set of resources, institutions, policies, actors, and actions that transform unimproved resources into food and other agricultural products demanded by consumers. *Priority products* mean those on-farm and off-farm raw, intermediate, and consumer products that have the greatest potential for contribution to agricultural transformation.

1.1.1. Working regionally to support national development

The case for regionalization recognizes the primacy of national systems in responding to the needs and opportunities

of national citizens. The regional approach provides innovative and improved ways of serving these national clients, either directly through regional actions or through regional support and harmonization of actions take at the national level. The critical value of a regional system is its success in working with national research and technology systems to strengthen national agricultures and economies.

The regional approach has two benefits. First, it allows the problems in national systems to be approached in a cost-effective way, using a common, regional framework that takes advantage of synergies among the systems. Second, it sends a signal to the bilateral USAID missions and other donors to support national system reform and gives the regional context for that reform.

1.1.2. Integrating agriculture and natural resources management

The current level of antagonism between agriculture and natural resources management (NRM) is so unhealthy as to threaten both agriculture and the natural resources upon which it depends. Natural resources management proponents correctly point out that stripping vegetation by land clearing, overgrazing, and fuelwood collection are the major causes of physical and chemical soil erosion in sub-Saharan Africa. They are also circumspect about agricultural intensification that encourages nutrient mining and chemical soil erosion. An example frequently cited is the elimination of fallow as cropping intensity rises. Proponents of agricultural intensification often view this concern as a brake on their activities. They correctly argue that increases in land productivity are critical in arresting degradation from extensification onto fragile lands and that agricultural intensification is the clear and perhaps only choice to move sub-Saharan Africa onto a positive economic-growth path. (In addition, SAATS will invest in technology systems to provide technical innovations for alleviating natural resource problems.)

It is conceptually unsound to regard productivity-enhancing agricultural technology development and transfer and natural resource management as separate concerns. Separation fails to take advantage of the huge complementarities available between natural resource management and agricultural technology development and transfer: "the productivity and well-being of Africa's agrarian and pastoral peoples is directly linked to the wise use and conservation of the natural resource base" (AFR/OTR, p. 1). SAATS will help redress this lack of coordination between agriculture and natural resource management by orienting activities toward the development and transfer of sustainable and profitable technology; that is, toward knowledge and techniques that improve, or at least maintain, the potential of the natural resource base, while at the same time increasing farm-level productivity to encourage agricultural and economic development.

The link between agricultural technology development and transfer and natural resource management to be fostered by SAATS is a very practical one: "only the farmers and herders—planting trees, controlling erosion, nurturing soil and water resources, managing woodlands and rangelands with a view to direct economic benefits for their families—can begin to make the substantial impact required to reverse the decline and

realize the full potential of the natural resource base" (AFR/OTR p. 2). Only an approach combining agricultural and natural resources concerns can provide farmers and herders with identical innovations that are both profitable and sustainable.

1.1.3. Increasing the role of African leaders

Although most African nations achieved political independence more than three decades ago, most national agricultural research systems are still beholden to developed countries. Donor funds are the preeminent source of operating budget for the national agricultural research institutes. Access to these funds often requires a national agricultural research institute to acquiesce to donor priorities and programs, which often are of limited interest to the host country. SAATS will attempt to invigorate the African priority-setting process and to provide funds for relevant, African-determined, priority areas.

Concurrently, Africans must grapple with and conquer the challenges of providing sound leadership and management of African institutions; of determining priorities based on sound economic, technical, and social analysis; of making African technology systems responsive to the needs of the people and consistent with democratic principles; and of generating domestic political and financial support for their agenda.

Box 2. National agricultural research systems and national agricultural research institutes

A *national agricultural research system* consists of the public, semiautonomous, nongovernmental, corporate, and other public-sector institutes, organizations, and participants with interests in agricultural technology.

The *national agricultural research institute* is the organization responsible for government-sponsored agricultural research. Typically this unit is under the jurisdiction of the Ministry of Agriculture, although it may be semiautonomous.

1.1.4. Building coordination and coalition around African priorities

Three fundamental tools will be used to convince donors to support the SAATS approach: institutional reform to support financial accountability and to improve the cost-effectiveness of research, development, and delivery; transparent determination of analytically sound technological priorities to stimulate economic growth; and the institution of financially sustainable funding mechanisms.

Box 3. Technical and technological change

In this document, the adjective *technical* refers to the techniques, processes, and products of on-farm and off-farm production activities. *Technological* refers to the study of techniques, processes, and products, including the systems that research, develop, disseminate, and use them. *Technological change* encompasses both technical change and institutional innovation in the technology system.

1.1.5. Initiating a demand-driven approach to technological change

The SAATS Initiative supports a demand-driven approach to technical change. Potential adopters of technical innovations demand certain characteristics, such as profitability; potential consumers of the outputs produced using these innovations demand quality products at affordable prices. A technology system that fails to recognize its clientele and their demands is doomed to failure.

SAATS will accommodate the demand-driven approach through

- Better links among public-sector organizations, such as research and extension services and universities.
- Better links with corporations, nongovernmental organizations, and other private-sector participants.
- Explicit consideration of client groups as equal partners in determining technological needs.
- Explicit consideration of the socioeconomic and political environments in determining priority areas for research and development.
- Co-stewardship of research and service outputs with their users.

The decisive institutional innovation is the sharing of stewardship responsibilities with the demanders of the technological innovations.

1.1.6. Leveraging USAID's and other donors' funds

SAATS will leverage funds in two ways: by identifying needed actions at the regional level; and by working with national agricultural research systems and donors, particularly but not exclusively USAID, to obtain funding, technical assistance, and nonproject assistance necessary to implement the appropriate national reforms.

By leveraging funds in these manners, a regional approach holds the greatest promise for coordinating donor and national actions in the region. It is also the best hope for restoring and eventually increasing the level of Agricultural technology development and transfer funding that prevailed in the early and mid 1980s.

1.1.7. Increased attention to consumer interests

An examination of agricultural innovation and its impacts shows that consumers are the major beneficiaries, usually from increased quantities of food and agricultural products available at more affordable prices. Consequently, consumers are the key clientele. An examination of rural smallholders in sub-Saharan Africa indicates that they are net consumers of staple foods. Hence, technological innovations directed toward helping consumers assist not just the general population but also the poor smallholders. SAATS will emphasize such innovations.

The most noticeable impact of increased attention to consumer interests will be a better balance of research resources between on-farm and off-farm activities. Explicit recognition will be given to the role of technical innovation in providing rural and urban consumers with market access to nutritionally adequate food supplies at affordable prices.

1.2. The PARTS project

SAATS is a Policy, Analysis, Research, and Technical Support (PARTS) project amendment. The purpose of this amendment is to increase the level of funding to the PARTS project and to extend the life of the project.

1.2.1. Background

The goal of the PARTS project is to contribute to sustainable increases in African agricultural productivity through more effective development strategies, policies, programs, and projects in the agricultural and natural resources sector. The project supports clients to increase their capacity and efficiency necessary to achieve project objectives through increased utilization and influence of information and analysis in the agricultural and natural resources sector in sub-Saharan Africa. Key project clients include Africans and African public and private organizations, USAID missions, REDSOs, the Africa Bureau, other USAID Washington offices, nongovernmental organizations, and other donors.

The PARTS project started in FY 1992 with an authorized life span of six years. It is managed within the Africa Bureau by SD and PSGE (the former ARTS and FARA). The PARTS project evolved from and consolidated a set of regional agricultural and natural resource management projects (the Strengthening African Agricultural Research and Faculties of Agriculture project and the Natural Resources Management Support project), which previously provided program support. The major mandate of the project is to support the clients mentioned above to improve the effectiveness of African institutions to alleviate the slow growth in agricultural-sector productivity caused by (1) inefficient marketing systems and weak support services for agribusinesses; (2) low utilization of high-yielding, profitable, and sustainable technologies; and (3) degradation of the natural resource base.

1.2.2. Previous regional programs

The final evaluation of the Strengthening African Agricultural Research and Faculties of Agriculture project concludes that "a well-funded, long-term, umbrella-type project focused on regional priority problems is needed." Characteristics of the suggested project include institution building; balancing biophysical research with social science research on policy, institutional, and economic issues; donor coordination; adequate funding; allocation of funds by priorities; and leadership by African national agricultural research systems.

1.2.3. Purpose of and rationale for the PARTS project amendment

The purpose of the PARTS project amendment is to integrate and provide support for the SAATS Initiative. The integration of the SAATS Initiative into the PARTS project will lower management costs for implementation and ensure that lessons learned from related analytical activities are incorporated into strategic development activities.

The SAATS Initiative builds on the lessons of the previous Africa Bureau regional programs and projects that have helped to evolve a strategy to bring the resources of LA, RCS, national agricultural research systems, universities, and nongovernmental organizations to bear on African problems and strengthen African national technology systems. This initiative will strengthen these linkages by playing a key role in implementing the ecoregional approach to collaborative regional research that the Bureau has actively promoted in Africa. It builds on the recent improvements made through the Special Program for African Agricultural Research initiatives to formulate subregional coalitions for revitalizing agricultural technology development and transfer systems in Africa.

The SAATS Initiative will promote and support subregional groupings of national and international research systems (including national agricultural research systems, international agricultural research centers (IARCs), regional research organizations, research networks, nongovernmental organizations, universities) for collaborative efforts on high-priority research themes and commodities. The initiative will modify and strengthen existing institutions, promote the harmonization of research priorities and strategies, and support regional collaboration at the technical and policy levels for technology development and transfer. It will also play a key role in leveraging resources and guiding the reform of regional and national systems by addressing key emerging issues such as regionalization, impact assessment and priority setting, institutional/financial sustainability, efficiency and accountability, public- and private- sector collaboration, and commercialization of technology.

The SAATS Initiative will need to develop and promote guidance for institutional reform of regional and national technology systems to achieve effective strategic planning, priority setting, and impact assessment. It will need to provide support for the transition to new institutional mechanisms and coalitions that will help shape and address the agenda for development in the twenty-first century. It will need to provide critical levels of support to sustain promising scientific work currently being given to production constraints, but jeopardized by the precipitous decline in funding—especially at the national level. And it will need to support the shift to a broader food systems approach to research and technology to include on-farm and off-farm constraints and strengthen the links between technology development, transfer activities, and agricultural transformation.

The SAATS Initiative will give significant amount to progress monitoring and impact assessment. In particular, it will institutionalize the capacity, methods, and indicators necessary to establish accountable research and development efforts. This will lead to more effective management by national and regional systems as well as donors.

1.3. Stakeholder analysis

Stakeholders with interests in SAATS include the participants involved in technology development and delivery institutions (national research and extension systems, international agricultural research centers, CRSPs, national and foreign universities, parastatals delivering inputs or including technical innovations, other public-sector agents, nongovernmental organizations, corporations and other private-sector agents involved in discovery and sale of planting or breeding materials, etc.); farmers, processors, wholesalers, retailers, and other potential adopters of improved techniques; consumers and potential consumers of currently produced outputs; consumers and other potential users of new and improved-quality products; donors; and national policy makers.

1.3.1. Interviews, field visits, and written comments

During September, 1994, surveys of SAATS stakeholders—national agricultural research institutes, international agricultural research centers, regional networks, private agricultural agents and farmers, private-sector associations and nongovernmental organizations, and other donors—were carried out in East and West Africa. The surveys were intended to ascertain stakeholder interests in SAATS and possible roles in its execution; to define SAATS regional programs in each area, and identify funding priorities and specific activities for top-priority attention; and to explore institutional capacities, deficiencies, and possibilities in the implementation of SAATS. Kenya, Ethiopia, and Uganda in the east, and Niger, Mali, Cotê d'Ivoire, and Senegal in the west were visited. Interviewers met with over 70 individuals across the range of stakeholders mentioned above, concentrating on national agricultural research systems and international agricultural research centers and donors. A list of persons contacted appears in appendix 4 of this volume.

Written comments or questionnaires were returned by over a dozen additional stakeholders. Nearly three dozen reports, technical papers, and documents have been prepared in support of the SAATS Initiative design.

1.3.2. Technical inputs and comments

None of the national systems visited has an ongoing priority-setting process. Some have undergone a priority-setting exercise in the past with mixed success. There are few useful lists of priorities from which to select priority areas for needed technical inputs, much less sound analysis of why these areas are priorities. Thus, the design document will have some difficulty in specifying technical actions.

A primary concern is to empower Africans to determine their own research agenda. Consequently, a deliberate effort was made not to be overly prescriptive in determining priority areas for technical intervention. With a few exceptions, specific commodities will not be selected or deselected for action.

Many stakeholders interviewed had considerable technical expertise and were African or had years of African field experience. Although the organization of most technology-system institutions along commodity lines makes it difficult to determine of priority commodities from stakeholder interviews, the clear need for livestock agricultural technology development and transfer emerged from many research system participants and from most if not all of the users of research system outputs. The importance of maize in East Africa and its potential in West Africa make this crop a candidate for further examination as a possible priority.

Three thematic areas for investigation emerged as consensus areas for support: social science and policy research, technology and inputs transfer, and food technology. Types of work in these areas to be done under SAATS include distribution of improved planting materials; variations on established food products, as well as new products for new markets; and studies of regional research priorities. Interest in the last item is so great that subregional activities have begun in each region—in the West, the Institut du Sahel is coordinating a priority-setting workshop via PRISAS; in the East, such workshops have been sponsored by USAID, REDSO, and ESA and the national agricultural research institute directors have constituted a regional social-science working group with Canadian International Development Agency and International Development Research Centre funds.

1.3.3. Political support

The base of political support for the goals of increased agricultural growth and competitiveness has been established by the ministers of agriculture throughout sub-Saharan Africa.

In their strategy for Eastern and Southern Africa, the ministers argue that there is a strong correlation between agricultural growth and overall economic growth in low income economies. This is overwhelming evidence that Africa is not likely to skip stages of development by industrializing on a weak agricultural economy. Moreover, agricultural growth leads to poverty reduction, equitable economic growth, employment creation, and food security. (Conference of Ministers of Agriculture, East and Southern Africa, p. 1).

The ministers go on to argue that what is needed is to put "agriculture on top of the political agenda, increase investment stability, and develop a more comprehensive policy framework" (Conference of Ministers of Agriculture, East and Southern Africa, p. 4). This includes greater commitment to technology development and transfer (Conference of Ministers of Agriculture, East and Southern Africa, pp. 4, 7).

The political message emerging from West and Central Africa is similar. In the framework for action for the humid and sub-humid zones, the ministers endorse a policy "to put the agricultural sector on the path to sustained growth" (SPAAR, 1994, p. 2). This policy includes technology development and transfer as key foci.

The political endorsement specifically included issues oriented toward regionalization:

- the establishment of a long-term strategy to define and sustain an integrated system of agricultural research,
- the need to establish a coalition of partners among those involved, as a means of promoting cooperation in priority areas of agricultural research,
- the need to strengthen agricultural research capacities at both the national and regional levels,
- the need to put in place a mechanism for the development and promotion of regional coordination and cooperation in agricultural research (SPAAR, 1994, p. 4).

The clear message sent by the ministers is that they desire faster agricultural growth and will use technology development and transfer as one means of achieving that growth.

1.4. The SAATS development paradigm

The SAATS development paradigm is the conceptual underpinning for using technology and support to technology systems to generate broad-based, sustainable, economic growth. It is the basis for developing integrated regional, subregional, and national strategies to increase the contribution of agricultural technology development and transfer to sustainable economic growth. It integrates and promotes a synergy between technical progress in traditional agriculture and natural resources management.

1.4.1. Agriculture transformation and economic growth

The fundamental SAATS development concept is that agriculture and natural resources can be managed to increase agricultural growth and to contribute to nonagricultural growth. The underpinnings of this concept are found in two empirical observations. First, most Africans and most of the poorest Africans are employed in agriculture. Second, there is a positive relationship between growth in the agricultural sector and growth in the nonagricultural sector.

Almost half the population of sub-Saharan Africa lives in absolute poverty (Pinstrup-Andersen and Pandya-Lorch). Most of the poor live in rural areas, often on fragile lands, and are employed in agriculture. The poorest of these poor often have insufficient landholdings to meet their subsistence requirements (Leonard; Weber et al.).

The positive relation between growth in the agricultural sector and overall economic growth is quantified empirically in Timmer, e.g., who finds that a one percentage point increase in the agricultural growth rate leads to an increase in the nonagricultural growth rate of 0.93 percentage points. In examining this relationship, Timmer finds that

> Several mechanisms can cause growth in agriculture to contribute directly to higher living standards for rural people while also stimulating growth in productivity for the entire economy.... In combination, these mechanisms should translate faster agricultural growth into measurably faster economic growth in aggregate, after controlling for the direct contribution of the agricultural sector to growth in GDP [gross domestic product] itself (p. 22).

The potential contribution of agricultural growth to overall economic growth leads Timmer to conclude that the agricultural sector is the desired starting point for the development process.

The process through which agriculture contributes to overall economic growth is known as agricultural transformation or structural transformation. Staatz describes the process of structural transformation as involving the long-run transfer of resources to the nonagricultural economy; greater reliance on markets rather than subsistence farming, due to specialization and exchange; and "increased access of individuals to knowledge systems of [the] wider world, as embodied in new technologies, management practices, and institutions" (p. 4).

Although in the long run there will be a voluntary transfer of human resources to nonagricultural production activities, in the short run, reliance on specialization, exchange, and new techniques and practices is facilitated by appropriate investment in the agricultural sector. Staatz goes on to argue that "the major policy issue is ... how to use investment in agriculture and the rest of the food system as a tool for transforming the structure of the economy, thereby increasing overall productivity and broad-based growth" (p. 1). Mellor argues that for countries whose economies are predominantly rural, "an agriculture-based growth strategy provides the only possibility of broad-based participation by the poor" (p. 127).

The SAATS strategy for agriculture-led transformation gives three roles to the food system: to help people feed themselves, to stimulate nonagricultural growth, and to develop new products and services. People are better able to feed themselves if they are able to produce more for their own consumption or if they able to generate additional income to have more flexibility in purchasing food. Four contributions from agriculture stimulate nonagricultural growth: release of agricultural labor to nonagricultural production, food production for the nonagricultural labor force, foreign-exchange generation, and purchase of nonagricultural goods by rural residents via market transactions (Johnston and Mellor; Staatz). The development of new products and services can contribute to income and foreign-exchange generation and enhanced exchange of agricultural and nonagricultural goods.

1.4.2. The contribution of technology to transformation and growth

It is clear that technology development and transfer has the pole position in stimulating transformation. Oram states that "technological change in agriculture is fundamental to economic growth, food security, and family welfare in developing countries" (p. 245). Examination of the record has led McClelland to conclude that "most countries have not achieved sustained economic growth without transforming agriculture; and the agricultural transformation has generally rested squarely on intensification and technical change" (p. 50). Consequently, SAATS focuses on technological change as a necessary condition for transformation and growth, and the most salient investment for stimulating such transformation.

The two fundamental characteristic of agricultural transformation most crucial to investment in technology are embodied in the release of labor to nonagriculture and the production of food for the labor force. First, it is impossible to increase food production and release labor without increasing labor productivity; it is nearly impossible to increase agricultural labor productivity without also increasing land productivity (yields). Second, production of food for the nonagricultural labor force means production, processing, transport etc. via a distribution systems that makes adequate quantities and qualities available at affordable prices. This requires productivity improvement in both the on-farm and off-farm components of the food system.

The role of agricultural technology development and transfer in the development paradigm is depicted on page 12 as figure 1. Technology development and transfer, funded by national, regional, and donor funds, appears at the upper left of the figure. The proximate outcome of successful, agricultural technology development and transfer is growth in agricultural productivity.

Increases in agricultural productivity (particularly labor productivity) facilitate the release of labor from agriculture to the nonagricultural sector, depicted by the arrow to the manufacturing-and-service-sector box. An innovative component of the SAATS strategy is to generate productivity-increasing techniques that result directly in improved manufacturing and service-sector performance. These techniques include the outcomes of off-farm research that increase productivity and profits or employment of postharvest manufacturing and service firms. Such outcomes might include improved milling techniques, better packaging that reduces transport loss, lengthening shelf life of processed flours and meals in retail outlets, the development of new products such as nontraditional exports, and so forth. It is this characteristic of development that leads to two of the desired characteristics of agricultural technology development and transfer: that agricultural technology development and transfer be demand driven and that it follow a commodity-sector approach (Strategic Framework).

Within the agricultural sector, increased productivity leads to increased food availability and lower prices for food and other agricultural goods. Food availability at affordable prices provides a general stimulus to nonagricultural business.

Lower food prices also directly increase the real wage rates of wide segments of the poor population. It is widely acknowledged that the real wages of nonagricultural laborers rise as food prices decline. What is less widely known is that a significant proportion of African smallholders are net purchasers of food staples, so that a decline in the price of these staples also increases the real incomes of these smallholder farmers (Weber et al.). Thus, Mellor's argument (p. 168) that "change in relative food prices is, in the short run, one of the most important determinants of change in the relative and absolute real income of low-income people" in many cases applies to the rural poor as well as the urban poor. Explicit consideration of "Weber households" (smallholder, net purchasers) and the desire for broad-based transformation will lead to decreasing food prices as an outcome-target for the SAATS activity.

Increased savings from poor, urban, and Weber households and from corporate reinvestment of profits will lead to capital accumulation and investment in nonagricultural production and processing techniques.

A second, innovative aspect of the SAATS paradigm is the fostering of linkages among capital accumulation and agricultural and nonagricultural technology. Capital accumulation could consist of livestock or agroforestry purchases or investments in land sustainability. Such investments will be facilitated if improved-quality capital goods (e.g., better livestock breeds, tree and shrub varieties, and natural resource management techniques) are available from the agricultural technology development and transfer system. Improvements in nonagricultural techniques may be complementary to improvements in agricultural techniques (e.g., development of a plant with medicinal characteristics may lead to innovation in pharmaceutical processing). Conversely, improvements in cold-storage techniques may lead to greater demand for nontraditional exports such as fruits, vegetables, or cut flowers, which may increase the benefits of agricultural technology development and transfer directed at on-farm production of these products. Finally, the bottom line is the well-established linkage between capital accumulation, technical change, and economic growth.

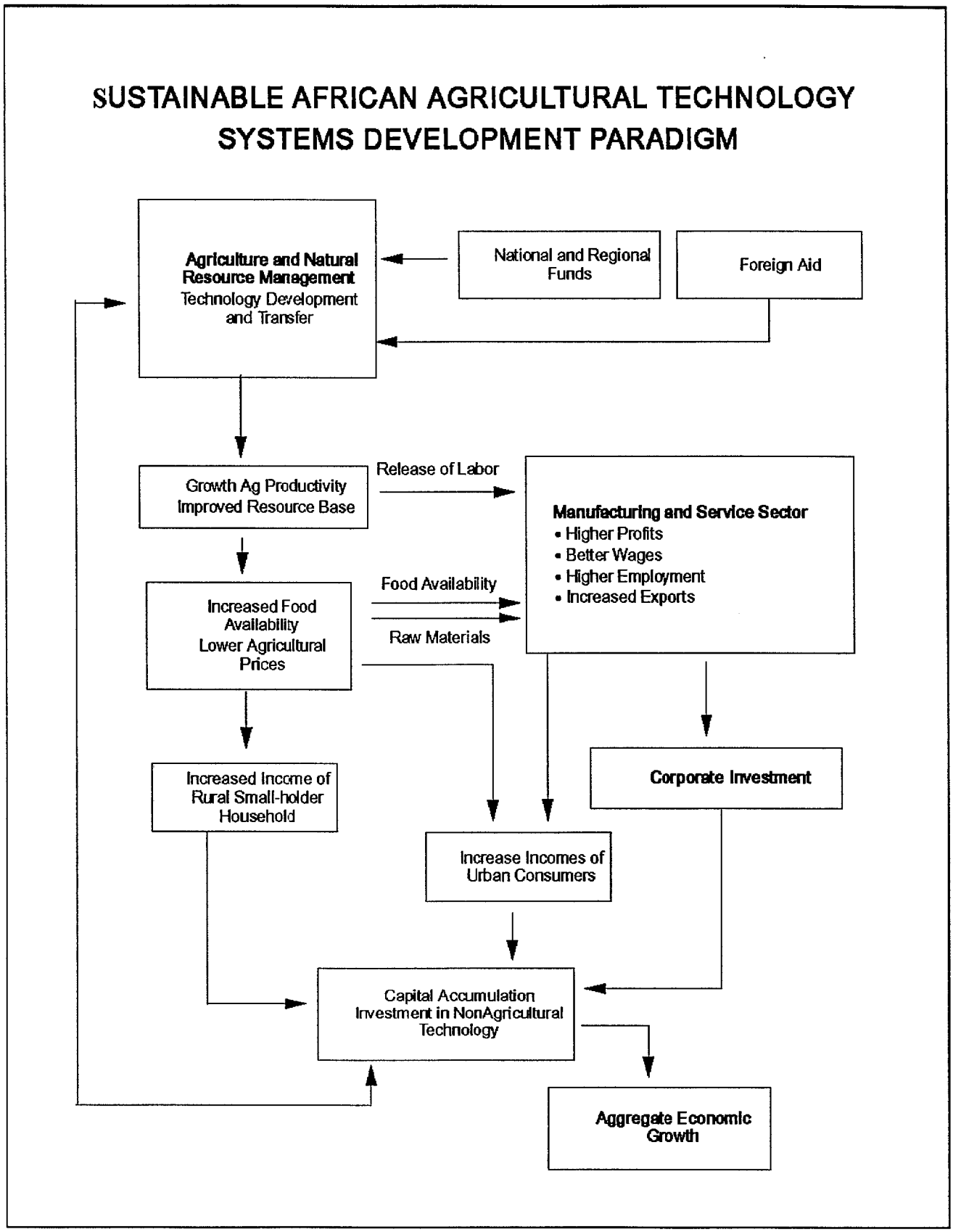
1.4.3. The commodity-sector–technology paradigm

The commodity-sector-technology paradigm shows where technology systems can contribute to improvements in the agricultural sector and assist agricultural transformation.

1.4.3.1. Commodity-sector–technology concepts

Traditional commodity-sector approaches focus on social and economic activities and interactions among people (grain compiling, trading, milling) and typically favor social interventions to facilitate these interactions. Although this perspective is not inherent in the commodity-sector concept, it recurs in applications of the concept that emphasize donor and government actions to facilitate socioeconomic processes such as subsidized output prices to promote farmers' selling to wholesaler. Neglected are the intermediate

Figure 1. SAATS development paradigm



products. Grain at the wholesale level is different from grain on the farm, not just because it is in a different position in the food system, but also because its physical characteristics may have changed during shipping and storage due to elapsed time. Technical innovations that would improve the quality of such intermedicate products tend to be neglected.

The commodity-sector–technology paradigm focuses on intermediate products rather than the social interactions that coincide with intermediate production activities. Technical innovations have physical manifestations, mostly in the form of improved inputs (hybrid seeds, more nutritious flour, etc.). Focusing on the physical inputs, intermediate products, and consumer products brings to the fore the possibilities for technical change.

A commodity-sector–technology diagram emphasizes the multiplicity of intermediate and final consumer products that are produced from raw products. Figure 2 depicts this idea for two subsectors: maize and cattle. The immediate outputs from maize production may be green maize, grain, and fodder. Cattle may produce manure, milk, meat, and cash if they are sold. Intermediate products such as land-tillage services may also be produced. Much as with the traditional commodity-sector approach, the technological approach traces these products through to the consumption of the final goods. Thus, maize grain may be refined into flours and sold in bulk by mills; these flours may then be packaged for retail consumption; and finally they may be purchased, cooked, and eaten by the consumer. Similarly, milk may be used to produce butter, which in turn is used to produce baked goods, which are finally eaten by the consumer. Each intermediate product is given a place in the diagram, and at each step in the diagram a new intermediate or final product is introduced.

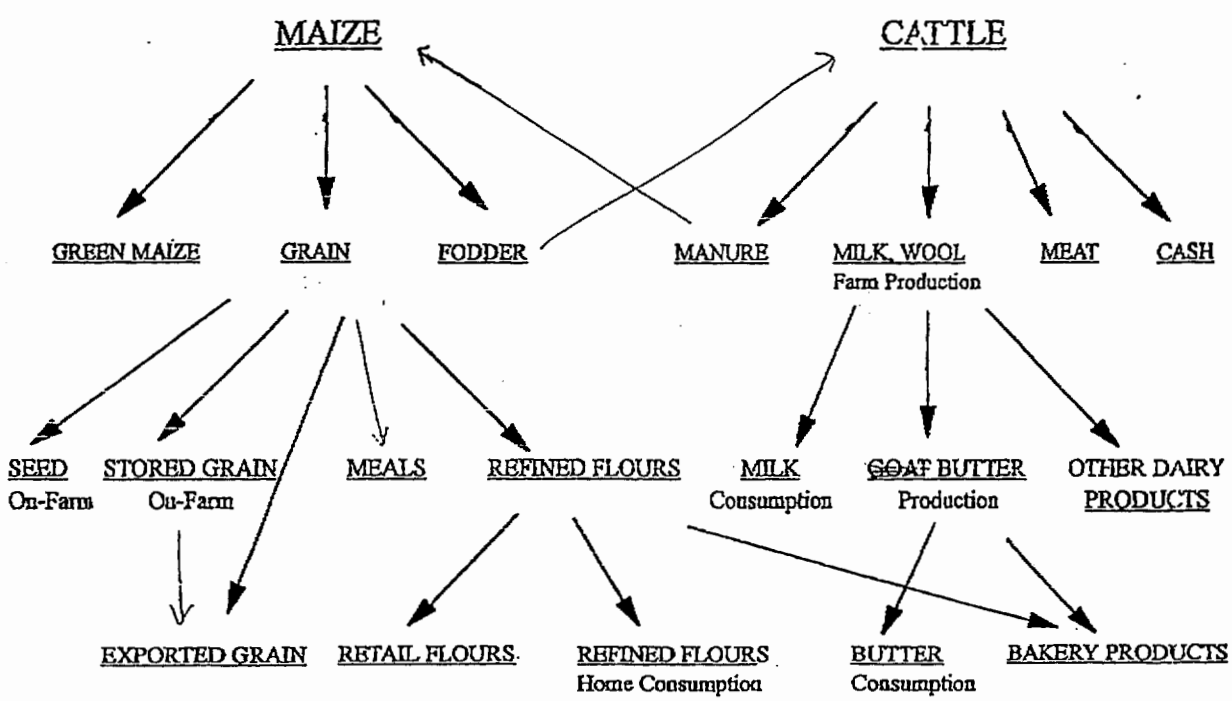
The commodity-sector–technology diagram is consistent with farming-systems and agroecological approaches. This compatibility is implicit in the impact of manure production on maize cropping and the availability of maize fodder on cattle production. A commodity perspective does not replace this farming-systems perspective, but it does add off-farm systems to the picture, enhancing the value of each perspective. For example, Meltzer finds that the nature of pastoralist livestock-farming systems influences the relationship between the milk and calves (which are intermediate products in the livestock-commodity system): "traditional production systems rarely provide supplemental feed during the dry winter months, and milk offtake for human consumption may stunt the growth of calves" (Volume 2: *Position Papers*, no. 5). Another example of complementarities between the commodity-sector and farming-systems approaches is the recommendation to replace monocropped maize on marginal lands with other small grains. A determination needs to be made on whether another grain requiring fewer resources to produce could be substituted for a monocropped maize crop, and whether the flour yield of both are comparable in quality. The demand for grain meals and flours of particular characteristics suggests important farm-level innovations, and farm-level opportunities

may suggest new products that can find a niche in the commodity sector. The commodity-sector-technology approach provides a conceptual guide to determining where such possibilities exist.

1.4.3.2. Application of the commodity-sector-technology approach

The fundamental tool for implementing the commodity-sector–technology approach is the commodity-sector account. Such accounts provide information on the inputs used in the production of each product, the value of these inputs, and the quantity and value of output produced. The commodity-sector–technology approach uses these accounts in the same fashion as the traditional subsector approach. These accounts are then used in a variety of ways to determine opportunities and constraints. Productivity indexes or other measures of international competitiveness can be calculated. A loss in productivity or competitiveness at the level of a particular intermediate product may signal a constraint or opportunity. For example, if Uganda produces oilseeds competitively for the wholesale

Figure 2. Illustrative commodity-sector-technology diagram for maize and livestock



market, but not vegetable oil, then there may be a bottleneck in the processing of oilseeds into oil. A different press or expeller mayrelieve this bottleneck. The subsector accounts are then used to construct enterprisebudgets to determine the profitability of potential technical improvements. For on-farm and other technical changes thought to affect the environment, natural-resource budgets would also be constructed and analyzed.

1.5. The SAATS institutional development paradigm

This section gives attention to (1) the experience gained in subregional networking and collaborative research systems, (2) commonalities and differences of existing initiatives, (3) mechanisms to coordinate or integrate various structures, and (4) guidance for evolution of ecoregionally based research initiatives to support institutional and technology development and transfer.

1.5.1. The systems framework for viewing an institution

An institution is a valued-infused organization that produces one or more products of value to society. An institution is also a multiphased production process. It transforms raw inputs into intermediate products, which, in turn, are further transformed in the production of end products that are injected into the using society. Finally, institutions are resource-using organizations.

The systems perspective of institutional development and performance as depicted in figure 3 suggests that there are two subsystems involved for most institutions. The first to be considered here is subsystem B, which depicts the final phases of the production process. Subsequently, attention will be turned to subsystem A.

1.5.1.2. Subsystem B—production of final outputs

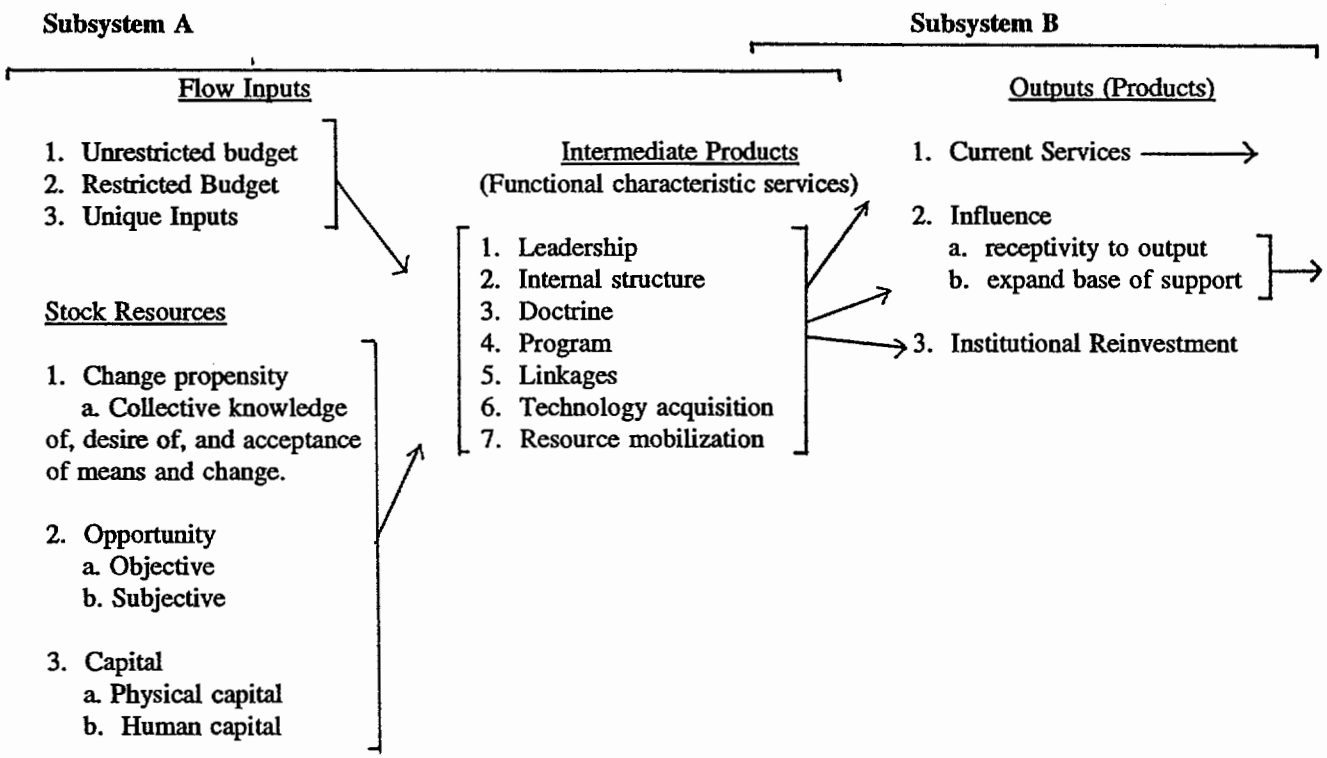
Three classes of outputs are depicted in the model: current services, influence, and institutional reinvestments. The first two of these are injected into the using society while the third is absorbed into the institution itself as it recycles through time.

Current services are the outputs that are usually associated with an institution. Universities produce graduates, development banks make loans, research institutions produce technology, etc. This category of outputs is the valued dimension of the institution with regard to the using society. Hence, this is the source from which the value ladened dimension of an institution emanates. Institutions differ from organizations with respect to the extent to which they are valued by the using of society. The supply of current services that an institution provides the using society largely determines the relative esteem in which it is held.

Influence is also an output of an institution. In fact, one measure of institutionalization is the amount of influence that it has on its environment relative to the amount of

influence that its environment has on it. The process of deliberately producing influence tends to center on two major foci. The first is an effort to influence the environment with regard to improving the receptivity of it to the current service output of the institution. The other focus consists of efforts to expand the base of support of the institution. Merely because an institution produces a flow of current services does not necessarily guarantee its sustainability. Rather, a planned effort to expand the base of support via exertion of influence by the institution on its environment is necessary in order to capture the full component of value that the society attributes to its current services outputs. (Attention will be returned to this point later in the discussion of alternative funding mechanisms.)

Figure 3. The systems approach to institutional development



Institutional reinvestments are analogous to the research and development expenditures made by private firms. They represent investments made by the institution at a point in time with a view toward improving the capability of the institution. Minimal reinvestments are needed just to maintain the capacity of an institution. Obviously, a growing, expanding one will require more. Especially in these cases, the opportunity costs of institutional reinvestments become apparent. A positive level of institutional reinvestments obviously is required for an institution to be sustainable. Sustainability is not a state to be attained but rather a continuous process.

All three categories of outputs share the characteristic of being the product of a transformation of intermediate products within the institution.

1.5.1.3. Subsystem A—intermediate products

The intermediate products are the services of leadership, internal structure, doctrine, program, linkages, technology acquisition, and resource mobilization. Some of these products are frequently referred to as functional characteristic services in the institution-building literature and have value insofar as they are retransformed into the outputs of the institution.

Leadership within an institution derives from formal and informal leaders. The development of leadership of both types is an extraordinarily important part of successful institution building. Past evaluation studies have revealed that successful institution building efforts result from "smart" projects. That is to say, there is enough leadership to perceive the changing circumstances and opportunities so that the institution can adjust over time. Clearly, a profile of both types of leadership before and after a technical assistance intervention should provide an indication of significant change, if the institution-building process has made progress.

The *internal structure* of an institution has a major impact upon the efficiency with which it operates. The process of adjusting and re-adjusting the internal structure of an institution, usually through a series of trial and error activities, is important in determining the most effective mode for its structure. In addition, the most effective mode may vary as its program adjusts to changing needs.

Doctrine is one of the most elusive intermediate products of an institution. In some respects it is analogous to the genetic coding of plants and animals. As its guiding philosophy, or "its philosophical superstructure" that justifies its existence, it can serve as a motivational device. Frequently, doctrine is manifest in the form of slogans. Doctrine changes slowly and is of crucial importance in determining whether the institution exists for the benefit of a few elites or functions in a service capacity for the entire society.

The *acquisition of technology*—in order for an institution to maintain its currency with regard to the state of the art—applies not only to its substantive dimensions but also

to managerial technology. Especially in the Third World, the process of attempting to acquire both types of technology is an expensive and never-ending process.

Resource mobilization involves not only acquiring financial resources, but, perhaps more importantly, involves attracting capable personnel to the institution. Resource mobilization finds itself manifest ultimately through the exertion of influence on the using society, as well as determining the human capital (staff) that the institution has at its disposal.

The intermediate products summarized above have one common characteristic: they all require resources. These resources fall into two categories: flow inputs and stock resources. These inputs interact in the process of producing the intermediate products.

1.5.1.4. Flow inputs

The budget dimension of flow inputs is in two parts: the restricted, and the unrestricted budget. The amount and flexibility of the budget are indicated by the ratio of restricted to unrestricted budget. This ratio is important in indicating autonomy, an important aspect of any institution being developed.

Each institution has a set of flow inputs that are unique to it. For example, universities must have incoming students, development banks must have loan applicants, research institutions must have problems posed for analysis, etc. These inputs are unique to the essential nature of the institution.

1.5.1.5. Stock resources

The three dimensions of stock resources are (1) change propensity, (2) opportunity, and (3) capital.

The *change propensity* of an institution is its collective knowledge of, desire for, and acceptance of the means of change. Institutions tend to have collective personalities. Some are very averse to change. The relative freedom from rigidity possessed by an institution is instrumental in determining its responsiveness to the changing needs of the society it serves.

Opportunity can be of two types. Objective opportunities are usually spelled out in the charter of the institution. Perhaps more important, however, is the matter of subjective opportunity. The perceptions of the leadership of the institution with regard to its opportunities to be of service are of crucial importance in determining how dynamic ("smart") an institution will be over time.

Capital is composed of physical capital and human capital. The former is the physical manifestation of the institution and is what frequently is thought of in the using society when the name of the institution is mentioned. Human capital, however, is undoubt-

edly more important in determining the effectiveness of the institution over time. Technical assistance efforts to augment and strengthen this dimension of capital can be expected to be of crucial importance in determining an institution's sustainability over time.

1.5.2. Dynamics of an institutional system

As an institution cycles through time, its institutional reinvestments expand or contract its ability to produce current products and services. Hence, these reinvestments warrant special attention.

1.5.2.1. Networking and collaborative research systems

Networking, a new name for an old practice, is a means of increasing the efficiency of agricultural research systems. Networks have become so popular, in fact, that questions are being asked about the characteristics of the most efficient ones. Generating efficiency turns on the fact that by sharing information and agreeing to a division of labor, a group of scientists can be more productive than the sum of their individual contributions. But this comes at a cost, primarily in the forgone opportunities that scientists would otherwise have taken advantage of while they are participating in network activities.

Plucknett, Smith, and Ozzediz contend that there are 14 principles required for successful networks. Acknowledging that not all authors agree to the same set of principles, they maintain that the following are essential: a widely shared researchable problem, participants motivated by self-interest, involvement of participants in planning and management, a baseline study that defines the research problem, a realistic research agenda based on that study, flexibility that facilitates midcourse corrections, a flow of new ideas and techniques, frequent face-to-face meetings, participants' voluntarily contributions of tangible resources, external funding commensurate with the type of network, participants adequately trained to undertake the research, commitment to stable participation and membership, strong and enlightened leadership, and a clearly defined scope of the network's task (Plucknett, Smith, and Ozzediz, 1990). SAATS would be well advised to ensure that these characteristics are present before allocating resources to new or existing networks.

1.5.2.3. Commonalities and differences of existing initiatives

In addition to networks, there are other regional groupings such as frameworks for action, consortia, and other ecoregional initiatives. Most tend to deal with small national agricultural research systems of relatively small countries, whose size precludes obtaining even at the national level the efficiencies that larger size will permit. However, most observers now express concern over the proliferation of these organizations.

Several criteria explain present groupings. In some cases, it appears to be agroclimatic conditions, in others language groupings, and in still others the preferences of the organizing institution. If USAID adopts a policy position to support Special Program

for African Agricultural Research, it would be well advised to follow that alignment of programs to the extent possible.

1.5.2.4. Mechanisms to coordinate or integrate various structures

Although no donor can expect to coordinate all the agricultural research initiatives in Africa, some lessons learned are noteworthy for the future. The one of foremost importance is the necessity of having management close to the research. At its extreme it would take the form of the empowerment of client groups exerting some control over the allocation of research resources. Working closely with donor representatives located on the scene, broadly based groups could influence the research agenda along the lines of relevant problems. This direction, when combined with scientist's knowledge of likely research payoffs, may realize more direct economic development benefits than agricultural research has yielded in the past.

Box 4. Lessons for management of regional research institutions

Three lessons are prominent from past management of regional research:

- Locate management within the region
- Empower local clients
- Utilize scientists' knowledge of likely payoffs

1.5.2.5. Guidance for evolution of ecoregionally based research

Two types of research appear to be underemphasized in Africa. One focuses on the interface between natural resource management and agricultural production research. The other focuses on post–farm gate research.

An analytical division seems to have arisen between natural resource management research and agricultural production research. The implication for institutional development is the need for new ways of stimulating collaboration between natural resource management and production-oriented activities. This requires incorporating natural resource management perspectives into commodity-based research and development activities and looking for increases in productivity of priority commodities with natural resource management activities. Obtaining acceptance of such alternative perspectives is a critical institutional innovation.

In the post–farm gate lies the major economic development potential. Increasing physical output at the farm level alone can result in price depressing surpluses in the short run and farmers skeptical of new technology in the long run. While the temporary price depressing surpluses will contribute to lower wage goods for a short period, the surpluses will ultimately disappear if farmers do not benefit financially. Therefore, research is needed not only on production problems but also on market expansion. Many of the economic development payoffs it will yield lie in the value-added area of agricultural commodities processing. Such research is not usually in the mandate of the international

agricultural research centers, and few national agricultural research institutes have the capacity to address the issues. Addressing postharvest issues will require new alliances with private-sector groups, new equipment, expanded training programs, and a refocusing of the research of some national agricultural research systems. This is the principle challenge of SAATS.

This refocusing should start with industry analyses participated in by both public-sector scientists and private-sector entrepreneurs. They need to be put in contact with the world stock of knowledge regarding commercialization. In turn, site specific research should focus on the knowledge gaps with regard to given locations. For example, maize utilization technology can be borrowed in large part with regard to production of starch, sweeteners, cereals, ethanol, and water-absorbing ingredients for filters, etc. But some of this technology may require modification to produce relevant technology in Africa. In almost all cases economic analyses will be needed in conjunction with physical science research in order to make the value-added industry competitive. Clearly, this will require close collaboration between the private and public sectors—probably to an extent not seen before.

This evolution of research initiatives should take place stepwise. First, regional host institutions must be identified. Second, they will need funding to sponsor industry analyses. Third, industry analyses including on-site information gathering by public and private groups in other parts of the world—and simultaneously the initiation of short- and long-term training programs to prepare the needed research talent. Fourth, economic feasibility studies to determine either where investments could be made immediately or what physical science research is needed to make investments feasible.

Physical science research and a streamlined production research program will be a continuing processes. Work on sustainable funding from patent revenues and check-off programs will also be phased in to supplement funding for agricultural research from traditional sources.

1.5.2.6. Functions necessary for effective collaboration

Coordination will be necessary at several points. The most difficult will be between the private and public sectors. In some African countries there is a deep distrust between the two. Bridging the gap will not be easy. One way of dealing with it is not only to make much of the program competitive but also to require that proposals must be joined by representatives of both sectors. This could start with opportunities to attend the industry analyses workshops. Selection of teams to travel to obtain on-site information would follow; after that, collaborative research, including economic feasibility studies. By structuring this type of interdependence an effort can be made to break down barriers between the public and private sectors.

To a lesser extent the same problem exists with regard to natural resources man agement and agricultural research groups. The same procedure is recommended to build collaboration and interdependence.

The basic host organization should be a regional group of research directors, which should be required to have an overall private-sector advisory group.

1.5.2.7. Empowering stakeholders and interest groups

Empowering interest groups and stakeholders through a private-sector advisory group requires that the group adequately represent the various stakeholders, that its advice is discussed seriously, and that resource allocations are made on the basis of these discussion. Institutionalizing this empowerment is new to agricultural research, and will proceed in unpredictable starts and stops. Empowerment usually means influencing priorities and resource allocation, however, and some general guidelines can be suggested.

Initially, short field visits should be used to determine who the stakeholders are and how to establish working relationships (t). Extended visits are the second step in establishing these relationships. In the third step, the clients' views are incorporated in a formal priority-setting process. The fourth step presents the outcomes of the process to the clients, strengthens the working relationship, and prepares for the next round of priority setting.

1.5.3. Governance of regional initiatives

Part of this topic has been handled above. The three points that have been made were (1) cooperate with Special Program for African Agricultural Research organizations, (2) use regional directors of national agricultural research systems as primary hosts, and (3) empower client groups to exercise some control over research resource allocation.

Consideration needs to be given to the flow and control of funds. In both East and West Africa a fiscal agent will be needed to handle SAATS funds until the directors of organizations are authorized to do so. To expedite the process, alternative arrangements should be considered. One would be to have Special Program for African Agricultural Research handle this responsibility. The other would be to route the funds through an international center. If procedures need to be developed in Special Program for African Agricultural Research, the latter arrangement could be used as an interim measure. Regardless, actions should proceed to obtain the necessary financial management capabilities in all of the participating countries.

Additional governance issues include the exchange of technical innovations, priority setting, contracting and granting, and accountablity of the national and regional institutions.

Table 1. Summary of *ex post* ROR studies for African agricultural TDT

Author(s) and date of study	Commodity, location, and years covered	ROR (%)	Comments
Abidogun, 1982	Cocoa, Nigeria	42%	
Makau, 1984	Kenya, 1922-1980, Wheat	33%	Econometric methods.
Evenson, 1987	Africa, Maize and Staple Crops	30-40%	Aggregate RORs by region. Econometric.
Karanja, 1990	Kenya, 1955-1988, maize	40-60%	Econometric. Statistical separation of research from extension; seeds.
Mazzucato, 1991	Kenya, 1978, maize	58-60%	Using Karanja data, finds minimal effect of fertilizer policy on ROR.
Mazzucato & Ly, 1992	Niger, 1975-1991, cowpea, millet and sorghum	< 0%	Non-adoption of varieties released in the study period.
Laker-Ojok, 1992	Uganda, 1985-1991, sunflower, cowpea, soybean	< 0%	Six-year study period used due to civil unrest in previous 15 years.
Boughton and de Frahan, 1982	Mali, maize, 1969-91	135%	Introduction of maize into cotton system by CMDT.
Ewell, 1992	East Africa, potato, 1978-1991	91%	Regional network/NARS collaboration.
Sterns and Bernsten, 1992	Cameroon, cowpea, 1979-1991 sorghum, 1979-91	3% <0%	ROR to research and extension.
Howard, Chitalu and Kalonge, 1993	Zambia, maize, 1978-1991	84-90%	ROR to research, extension, seed distribution, and additional production inputs.
Schwartz, Sterns and Oehmke, 1993	Senegal, cowpea, 1980-85	31-92%	ROR to research-based famine relief includes all aspects of TDD.
Sanders, 1993	Ghana, maize, 1982-1992	74%	Starting date determined by initiation of SAFGRAD program.
Smale and Heisey, 1994	Malawi, maize, 1957-1992	4-7%	Improved research performance since 1985.
Kupfuma, 1994	Zimbabwe, maize, 1932-1990	43.5%	Research and extension activities of the Dept.of Research and Specialist Services

SOURCE: Oehmke, 1994.

1.5.3.1. Exchange of technical innovation among private and public agents

Because African research institutions need to seek alternative funding for their programs, some of the research under SAATS should be dealt with accordingly. That is to say, patentable products and procedures will need to be protected as soon as possible after discovery. Assuming that much of this work will be funded by SAATS via jointly submitted proposals, patents will often need to be in the name of public and private organizations.

In instances where no patenting is possible, free flows of technology should be facilitated via workshops, consultancies, professional meetings, etc. Most of the latter should be organized on a regional rather than a national basis.

1.5.3.2. Priority setting

Caution must be exercised to maintain a balance in the research program between technology to be shared freely with all and that which is patentable. Either extreme would be unfortunate. One method of keeping research programs in focus is by having clear focus on future needs. Hence, one of the aspects of the industry analyses should be to make needs projections for five and ten years. This will yield counterbalancing information, i.e. there will be an indication of processing opportunities as well as domestic consumption requirements. In many cases these will be mutually supportive. But in other cases they will be competitive and, in that event, caution is in order.

1.5.3.3. Review and award of competitive research grants

Two additional comments are in order with regard to competitive research grants. The first is that the decision-making group allocating these funds should be members of client groups and peers of those submitting proposals. The other is that preproposals should be requested in order to reduce the amount of time scientists spend writing proposals. A short list of finalist preproposals should be determined by the evaluators; only those should then submit full proposals.

1.5.3.4. Measure to determine accountability of institutions

Three aspects of institutional accountability are worthy of consideration: financial management, performance (in terms of the output of current services), and infusion of value. The first two are short-run phenomena; the last is long run in nature.

Financial management has tended to be a problem in some research institutions. Although a complete discussion of financial management requires far more elaboration than justified here, serveral important aspects deserve mention. First, the financial management system requires that funds be tracked by project. Standard accounting procedures can be used in designing the system to ascertain that the project be the unit of account. Likewise, standard auditing practices should be used to assure appropriate use of funds. In this regard, one specific suggestion is shared. It is the practice used by the U.S.

Government with regard to the Agricultural Research Service. At any time auditors can arrive unannounced at any location—even the most remote ones—to ascertain that all funds can be accounted for properly. The mere possibility of such an unannounced visit is thought to be very important to financial management. Regardless, standard training and auditing practices need to be clearly specified at program inception.

The second short-run aspect of accountability concerns the output of current services. In this case, the output is primarily technology. This is a matter mostly for evaluation by peer scientists and members of client groups rather than accountants. One design feature in this regard, mentioned earlier, is the empowerment of client groups with partial control over the allocation of research resources. Of import is the principle that not only should an adequate volume of technology per dollar of expenditure be produced but also the technology should meet the needs of those expected to implement it. Clearly, regular evaluations of programs by groups representing both the scientific community and user groups should be standard operating procedures.

The final aspect of accountability is long run in nature. In order for any institution to be sustainable it must be infused with value. This dimension primarily applies to the basic units doing the research as opposed to the organizations through which funds are passed. While the latter may be reconfigured from time to time, especially with regard to donor preferences, the basic unit producing the technology needs to be managed so the support it needs will come from the clients it serves. This means that the influence output of the institution must be carefully managed. A detailed long-range plan should be developed for each research unit and updated annually by its management and advisory groups. Some of the financial dimensions of such plans will be discussed in the sections that follow, but recognition should be given to the fact that these long range strategic plans involve far more than just financial aspects.

1.5.4. Sustainable funding mechanisms

Primary financial support for agricultural research in the public sector in most countries comes from government appropriations. The justification for this will be reviewed after considering nontraditional funding sources not usually emphasized in Africa: patent revenue, debt conversions, check-offs, and endowments.

1.5.4.1. Patent revenue

Patents will provide not only the protection mentioned above but also a source of revenue for both research institutions and scientists. Enabling legislation is needed to make patent protection possible, which was alluded to above. And the patent-generated revenue stream needs to be managed. This requires such things as marketing the patent rights, oversight to ascertain that the proper amounts are paid (frequently these are based on number of units produced, which requires correct counting of outputs) and vigilance against patent infringement. In a competitive world, patents will not manage themselves. They can be an important source of revenue for a research institution but they must be managed.

1.5.4.2. Debt conversion

In countries where nonperforming debt is outstanding, a leveraging procedure can sometimes be used to increase the purchasing power of donor funds. Several steps are involved. First, a grant is made by a donor to an implementing agent usually in the donor country. The implementing agent uses these funds to purchase the nonperforming debt at a discount from the bank holding it. Third, the debt is sold to the host country central bank usually at a lesser discount payable in local currency over a period of time. These funds are used to finance jointly conducted research by the host research institution and the implementing agent from the donor country.

Two characteristics of debt conversions deserve emphasis: (1) they usually result in a larger research budget for the joint project and (2) they will be possible only if all the parties feel they have bettered their position by participating. Though not a panacea, debt conversion can be very helpful in some situations.

1.5.4.3. Check-offs

Check-offs are voluntary programs undertaken under government supervision. The steps involved in implementation are as follows: (1) legislation that enables the program, if voted upon favorably by producers, (2) voting on a check-off by eligible producers, (3) if the vote is favorable, collection of a very small assessment at the point of first sale of a commodity, (4) allocation of funds collected by an elected board of producers, and (5) refund of funds to individual producers if requested under a procedure supervised by government.

Although not used exclusively for research, these funds have become an important source of research monies in several industrialized countries. Surprisingly, as a result of decisions made by the elected boards, much of the funding is used in the United States for utilization rather than production research.

1.5.4.4. Endowments

Usually held by foundations or similar organizations, endowments are blocks of invested funds (corpus) the income from which is used to fund research. Both public and private donors have been involved in creating endowments in Latin America, where several successful institutions have been created (e.g., FUNDAGRO in Ecuador and Fundación Chile).

Endowments have several advantages. First, they facilitate rapid investments in assets that appreciate with inflation. Second, they create a stream of income, which provides a flow of funds to the research organization. Third, they permit an allocation of funds for competitive grants as well as regular appropriations. Fourth, they create a stable, sustainable funding source for the research institution. The principle challenge of an endowment is to expand its corpus continually.

1.5.4.5. Traditional research funding

The four above-named nontraditional funding sources are supplements to and not replacements for traditional government funding of agricultural research. The basic rationale for government funding is clear. Research can reduce the costs of food (wage goods), increase the supply of feedstocks for value-added processing, and increase the demand for purchased inputs by the farm sector, thereby stimulating economic development. In a market-oriented economy the consumer is the primary beneficiary of output-enhancing agricultural research in the long run. While early adopters in production agriculture initially enjoy short-run gains due to lower production costs per unit of output, these short-run gains are lost to early adopters as the new technologies are adopted industry wide. The long-run reduction of food costs accrues to consumers. It is therefore in their best interest to support agricultural research. When the potential of expanding the agricultural business sector is added, there is considerable justification for government funding of agricultural research.

1.5.5. Concluding comments on the institutional development paradigm

As the initial section of this report suggested, in order for an institution to become infused with value it must produce current services and influence for the using society. SAATS can aid in that process. But to do so requires working with institutions, many of which will be regional as well as national. This means that these tasks will be quite difficult given the low proportion of regional activity as contrasted to national. Ultimately, the national agricultural research system will need to be infused with value. This can occur with careful management and the achievement of a track record demonstrating that agricultural research can be one of the "engines" of development.

2. The regional context

2.1. Historical context

The twentieth century has witnessed agricultural transformation that has fueled tremendous economic and social change. Such changes could not have occurred without the advances brought about by scientific agriculture in Asia, Europe, North America, Oceania, and South America. Africa has benefited less than the other continents, and in general, its agricultural performance has lagged. So, too, has its economic development.

The agricultural growth rate in most sub-Saharan African countries is half or less than half of the 3.25 percent per year needed to generate increases in per capita income. An International Food Policy Research Institute (IFPRI) study of global food needs concludes that Africa must triple its production—much of it by increasing crop yields at least threefold—by 2025. Some experts consider African agricultural performance to be dismal at best, citing stagnant or declining aggregate statistics such as gross national product or per capita food production. But this is not the full story.

There are some bright spots. Growth in rates of yield for certain crops have increased modestly in several countries over the past twelve years: e.g., yams in Gabon, Nigeria, Benin, Guinea, Chad, Cotê d'Ivoire, Central African Republic; millet in Tanzania, Burkina Faso, Ethiopia, and Senegal; pulses in Nigeria; plantains in Uganda, Rwanda, Ghana, Zaire, and Nigeria; cassava in Cameroon (highest rate of gain for the world over the period), Uganda, Nigeria, Madagascar, Zaire, Angola; maize in Cameroon, South Africa, Burundi, Ghana, Kenya, Somalia; root crops in general in Nigeria, Zaire, and Uganda. Other examples could be mentioned.

While research in Africa has not yet brought this transformation to all countries, research can and does pay dividends. The question is, How can agricultural research be organized better to identify problems and opportunities and plan for their effective solution, thereby to create a favorable climate for agricultural transformation?

Some observers believe Africa was "dealt a bad hand" as regards its natural resource endowment. Careful study by a group of Dutch scientists shows, however, that Africa does not rank lowest among the continents as far as potential agricultural productivity is concerned. Indeed, Africa ranks second, not far behind South America. The continent that ranks lowest in productive potential is Australia, where highly productive agriculture is practiced. Why, then, does Africa lag in agricultural productivity and overall performance? The answers are complex, involving a lack of government commitment to agriculture and its improvement, weak technology innovation and transfer systems, weak institutions, and a difficult production and marketing environment for producers.

Agricultural research in Africa is not faring well. Despite increased numbers of scientists and emphasis on improved institutions, support per scientist is declining and overall support is very dependent on outside donors. Institutions are not functioning as

well as desired, in part because of a lack of effective strategic planning. A framework is needed that would allow for improved strategic planning from the farm to the marketed product. It should involve African scientists and stakeholders in improving the supply and flow of needed technologies. This framework should also provide a means for effective outside help to ensure productivity growth that will lead to agricultural transformation.

Agriculture in Africa has been further impeded by civil war and social disorder, government incapacity and instability, periodic drought, pests and diseases, and lack of capital. These impediments have made Africa the recipient of billions of dollars in relief and recovery assistance to help alleviate famine, most recently in Ethiopia, southern Africa, and Rwanda. Today, USAID spends more in relief assistance in Africa than it does on development assistance. Given the research necessary to produce the inputs and devise the methods that disaster recovery food production campaigns require, the shock of disaster and the stress of recovery may set the stage for accelerated agricultural transformation in these afflicted areas.

2.2. Returns to past investments in African agricultural technology development and transfer

Following the Berg report and other indictments of African national agricultural research institutes, African agricultural research fell into disrepute in the 1980s. Coupled with stagnant economic growth in the 1970s, the recognition of problems within the national agricultural research institutes led to a general air of discouragement and Afropessimism. Against this backdrop, USAID's support for African agricultural technology development and transfer declined from $55 million in 1986 to $35 million in 1991; real (inflation-adjusted) levels saw a larger decline (Oehmke).

The pessimism was based largely on statistics related to but also tangential to the effectiveness of agricultural technology development and transfer. Indictments of national agricultural research institutes looked at inputs; they did not look at what entrepreneurial scientists were able to achieve under these stressful conditions. Aggregate statistics such as food production per capita show the failure of population planning activities more than the failure of agricultural technology development and transfer. The pessimistic view did rest squarely upon investigations into the outputs of agricultural technology development and transfer and the impacts thereof.

The primary indicator of the efficiency of agricultural technology development and transfer in generating social impact is the rate of return. The rate of return is a single number that captures the essence of the time path of costs and social benefits associated with the agricultural technology development and transfer program. A rate of return that exceeds the market interest rate or the cost at which the government can generate funds (the opportunity cost of capital) indicates a program that has been successful economically. As a rule of thumb, the real opportunity cost of capital usually lies in the 3 percent to 15 percent range.

Prior to 1990, there were only three published rates of return to African agricultural technology development and transfer (table 2). Following impact assessment activities commissioned by USAID and others, at least fifteen studies are now available. Each of these studies finds that agricultural technology development and transfer has had impact. Eleven of the fifteen studies indicate that the benefits arising from agricultural technology development and transfer are sufficiently large to justify the investments, with rates of return in excess of 15 percent.

An interesting interpretation of the rate of return results is found by comparing them with the returns to other investments (figure 4). For example, most of the rate of return numbers presented exceed the return to investments in stocks as measured by the Dow Jones Industrial Average, which showed a 14 percent increase in the relatively good year of 1993. The highest rates of return in Africa are comparable to the highest rates of return found in other parts of the developing world. For example, the 135 percent rate of return to the introduction of maize into the Mali Textile Development Company zone in Mali exceeds the 133 percent rate of return to Indonesian rice, the highest found rate of return to investments in Asian agricultural technology development and transfer.

The rate of return studies do not deny the severe problems currently existing within national agricultural research systems and other components of African systems of agricultural technology development and transfer. What they show is that important accomplishments have been made despite these problems. The implications for action are three: (1) that current, real, funding levels for agricultural technology development and transfer should be maintained for the immediate future; (2) concurrently, institutional reform should be undertaken and supported; and (3) in the medium term (2–5 years) real levels of funding should be increased as agricultural technology development and transfer institutions complete the critical steps in the reform process, become viable organizations to support agricultural technology development and transfer, and have the capacity to manage and spend additional funds.

2.3. Socioeconomic and agricultural sector indicators

The simplest application of socioeconomic indicators is to characterize grossly the distinguishing features of the national and regional economies and agricultures. For example, in the humid and subhumid region of West and Central Africa, daily caloric intakes have risen slightly and are at minimum acceptable levels, despite a recent decline in food production per capita (table 3). This suggest that the region has some flexibility in meeting future demand from a growing population for food, through increases in production and through increased trade.

Table 2. Agricultural, land use and production indicators, by FFA region

Indicator[a]	East/Central	Humid/Sub-humid	Sahel
Agriculture			
% of GDP, 1991	41 %[b]	33 %	
Growth, 1970-80	2.7 %[c]	2.3 %	
Growth, 1980-91	2.1 %[c]	2.4 %	
Food, % of Imports			
1965	n.a.[d]	15 %	
1970	n.a.	16 %	
1991	n.a.	18 %	
Ag, % of Exports			
1965	n.a.	55 %	
1970	n.a.	59 %	
1991	73 %[b]	47 %	
Land use			
Land Area	9,096,000 km^2	601,971,000 ha.	
Arable Land	n.a.	52,325,000 ha.	
Permanent Crops	n.a.	8,507,000 ha.	
Permanent Pasture	n.a.	115,391,000 ha.	
Forest Woodland	n.a.	326,294,000 ha.	
Other	n.a.	99,274,000 ha.	
Irrigated Area	n.a.	1,067,000 ha.	
Ag. production			
Crop Index, 1974	n.a.	93	
Crop Index, 79-81	n.a.	100	
Crop Index, 1992	n.a.	130	
Lvstk. Index, 1974	n.a.	77	
Lvstk. Index, 79-81	n.a.	100	
Lvstk. Index, 1992	n.a.	152	
Crops/capita, 1974	n.a.	109	
Crops/capita, 79-81	n.a.	100	
Crops/capita, 1992	n.a.	90	
Lvstk./capita, 1974	n.a.	91	
Lvstk./capita, 79-81	n.a.	100	
Lvstk./capita, 1992	n.a.	105	

[a] Due to some countries participating in more than one FFA, double-counting across regions may occur.
[b] Arithmetic mean of country figures, 1990.
[c] Arithmetic mean of available, country growth-rates.
[d] Not available from FFA document.

SOURCE: SPAAR (FFA Documents).

Gross socioeconomic indicators may also give information specific to the agricultural sector. For example, in the humid and subhumid region of West and Central Africa, the land area in permanent pasture is twice the arable land area (table 4). This suggests that livestock may be a priority component of the agricultural system for a large portion of the land. A second type of socioeconomic indicator is commodity specific. It is useful to know the contributions of different commodities to food production, foreign exchangecommodities to food production is the relative importance of these commodities in the current diet. For example, the three commodities contributing most to the diet in Equatorial Africa and Humid West Africa are cassava, rice, and maize. This is an indication that research to increase food availability should consider targeting one or more of these commodities. Research targeting increases in agricultural GDP should perhaps give priority to plantain and banana, as it is among the top three contributors to production value.

2.4. Justification for regional action

2.4.1. Justification for action

Africa has seen neither agricultural transformation nor a Green Revolution on the scale found in Latin America and Asia. Most of sub-Saharan Africa, real income per capita has been stagnant or declining. A necessary condition for agricultural transformation is increased productivity of the off-farm portion of the agricultural sector (processing, shipping, wholesaling and retailing, and preparation).

Four critical conditions have prevented technology systems from realizing their full potential contribution to agriculture and agriculture transformation. (1) Research institutions, both at the national and regional level, are inadequate. The result is poorly coordinated research that does not always address priority concern or meet the needs of users. (2) The lack of a sufficient enabling environment has diminished the profitability of new techniques, holding down adoption levels and intensity. With structural adjustment, many of these constraints have been eliminated. Some remain. (3) The postharvest sector has been neglected. This means that consumers have not realized the full potential benefits of reductions in prices and improvements in quality that are available from proper investment in postharvest agricultural technology development and transfer. It also limits the profitability to the farmer of adopting innovative techniques, and impedes the postharvest sector to provide employment. (4) Inadequate distribution and transfer results in many promising innovations lying unused. The inadequacies stem from poor research/extension coordination, ineffective extension systems, and a poor policy environment.

Currently, national and regional institutions are failing to improve these four conditions. The primary cause of this failure is institutional malfunction. There is desperate need for institutional reform, followed by assistance to address the remaining constraints to the effective use of agricultural and natural-resource technology systems in stimulating agricultural growth and transformation.

Table 3. Summary of *ex post* ROR studies for African agricultural TDT

Author(s) and date of study	Commodity, location, and years covered	ROR (%)	Comments
Abidogun, 1982	Cocoa, Nigeria	42%	
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Evenson, 1987	Africa, Maize and Staple Crops	30-40%	Aggregate RORs by region. Econometric.
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Sterns and Bernsten, 1992	Cameroon, cowpea, 1979-1991 sorghum, 1979-91	3% <0%	ROR to research and extension.
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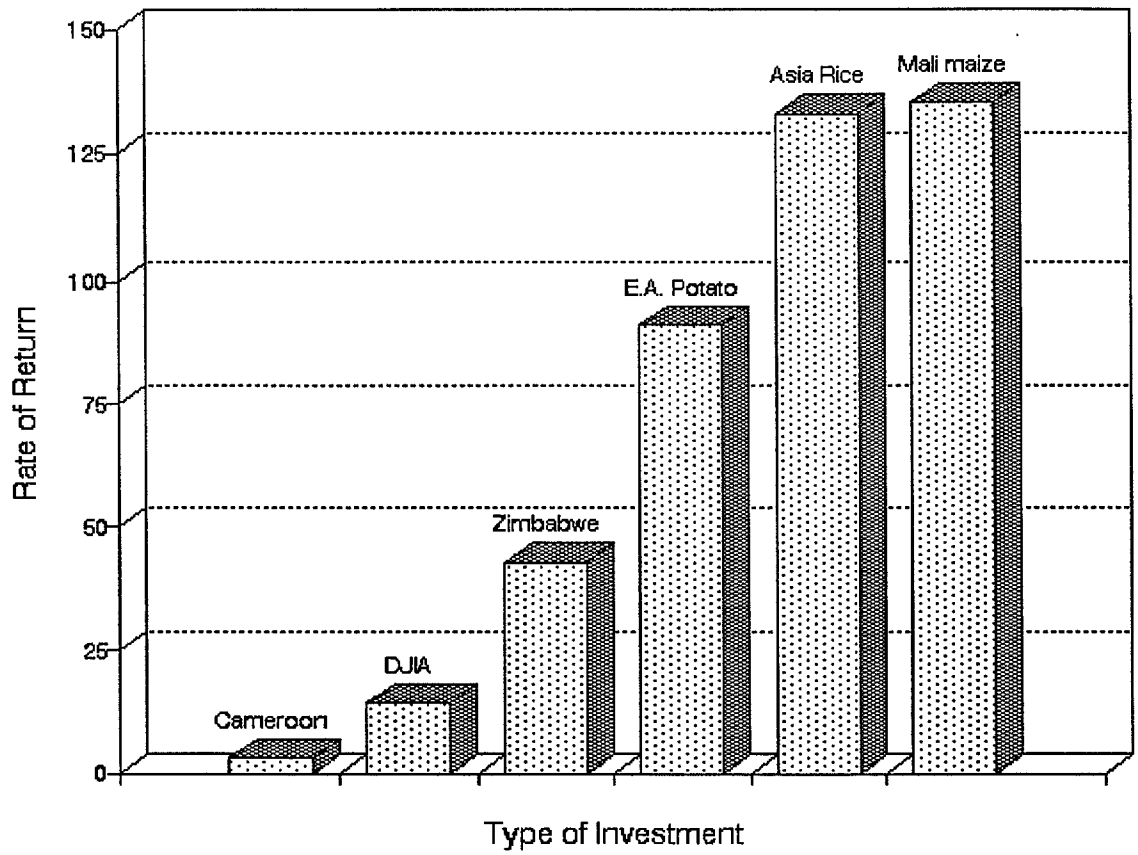
Smale and Heisey, 1994	Malawi, maize, 1957-1992	4-7%	Improved research performance since 1985.
Kupfuma, 1994	Zimbabwe, maize, 1932-1990	43.5%	Research and extension activities of the Dept.of Research and S

SOURCE: Oehmke, 1994.

Figure 4. Comparative rates of return to selected investments, including TDT



"Cameroon" represents the rate of return to cowpea TDT in the North-Centre province, 1979-91.

"DJIA" represents the returns to the Dow Jones Industrial Average, 1993.

"Zimbabwe" represents the returns to hybrid maize TDT in Zimbabwe, 1932-90.

"E.A. Potato" represents the returns to potato TDT in East Africa, 1978-91.

"Asia Rice" represents the returns to rice TDT in Indonesia, 1965-77. This represents the highest published ROR to investments in Green Revolution TDT in Asia.

"Mali maize" represents the returns to TDT over the period introducing maize into the CMDT zone of southern Mali,

SOURCE: Oehmke, 1994.

Table 4. Population and nutrition indicators, by FFA region

Indicator[a]	East/Central	Humid/Sub-humid
Population		
Population, 1991	222.3 million[b]	204.5 million
Annual Growth Rate		3.1 %
1980-1991	n.a.[c]	2.9 %
1991-2000	n.a.	
Food & Nutrition		
Daily Calories		
1965	n.a.	2136
1989	n.a.	2245
% Change	n.a.	0.2
Food Prod./capita		
1965	n.a.	104
1974	n.a.	106
1979-81	n.a.	100
1992	n.a.	92

[a] Due to some countries participating in more than one regional FFA, double-counting across regions may occur.
[b] 1990.
[c] Not available from FFA documents

SOURCE: SPAAR (FFA Documents).

Table 5. Priority rankings of food commodities by region and by production and diet shares, 1979–81

Equatorial Africa	Humid West Africa	Semi-arid West Africa
	Ranking by value of production share	
1. Plantain/banana	1. Yam	1. Yam
2. Sweet potato	2. Rice	2. Millet
3. Rice	3. Plantain/banana	3. Beef
4. Beef	4. Cocoyam	4. Cocoyam
5. Cassava	5. Oilpalm	5. Groundnut
6. Yam	6. Maize	6. Sorghum
7. Fieldbean	7. Groundnut	7. Sheep and goats
8. Maize	8. Beef	8. Cowpea
9. Groundnut	9. Cassava	9. Milk
10. Millet	--	10. Rice
	Ranking by calories/protein shares in the diet	
1. Cassava	1. Rice	1. Millet
2. Rice	2. Maize	2. Sorghum
3. Maize	3. Cassava	3. Yam
4. Fieldbean	4. Yam	4. Rice
5. Groundnut	5. Wheat	5. Maize
6. Plantain/banana	6. Plantain/banana	6. Cassava
7. Millet	7. Oilpalm	7. Wheat
8. Beef	8. Groundnut	8. Cowpea
9. Sweet potato	9. Cocoyam	9. Wheat
10. Wheat	10. Millet	10. Cowpea

SOURCE: Jahnke, Kirshcke, and Lagemann, Table 3.2, pp. 39–40.

2.4.2. Justification for acting at the regional level

A regional approach to increasing agricultural productivity has two thrusts: to assist the national agricultural research systems with the institutional reforms that will make them more effective systems of agricultural technology development and transfer, and to coordinate the areas of technical investigation that are most cost-effective when carried out at the regional level.

A regional umbrella organization has a comparative advantage in catalyzing institutional innovation at the national level. Working through a regional organization, the SAATS Initiative can animate multiple national agricultural research systems at once, encouraging innovations needed among many such systems of the region. In order to achieve this animation, SAATS should focus on institution-building actions that satisfy the following criteria:

- The support is requested by one or more of the following: (a) a national agricultural research system; (b) constituents for assistance with a well-defined problem or opportunity.
- The support is part of the regional mandate endorsed by the regional organization or its oversight committee.
- The national agricultural research systems or their parent organizations commit to the national actions necessary to achieve the intended reform.
- The action taken by the regional organization is complementary to the interests of other national systems within the region.
- The action taken by the national agricultural research system is complementary to the other national systems within the region.
- The regional organization has a comparative advantage in providing the requested support (it is more cost-effective to deliver at the regional rather than national level).

Specific institutional innovations and SAATS actions to support them are discussed in the Plan of Action.

The second advantage of the regional approach is enhanced cost-effectiveness of national agricultural research systems. These enhancements occur because of several advantages of the regional approach, including

- Availability of a critical mass of scientists and knowledge at the regional level.
- Better genotype x environment and technology x environment trials.
- Less redundancy of research, testing, and screening activity.
- Improved distribution of public research goods, particularly new knowledge.
- Improvement and standardization of new research methods, knowledge of process and mechanisms, allowing for enhanced reliability, comparison, and borrowing of research results.

- Standardized testing and certification methods reduce costs of transferring inputs or outputs across national borders.
- Regionalization ameliorates impact of political instability on technical knowledge and research results.
- Greater scope for dealing with Africa's diverse agro-environment.

3. The SAATS program strategy

The SAATS Initiative is designed to target USAID's priority area of economic growth. Without a viable and growing agricultural sector, sub-Saharan Africa will not experience economic growth.

The design explicitly incorporates USAID's priority of environment through linkages with natural resource management and natural resource technology development. The priority of democracy and governance is incorporated through the empowerment of Africans in determining and implementing the agricultural research and development agenda.

The priority of democracy and governance is also furthered by targeting economic growth through agriculture. "Agricultural development in [West and Central Africa] encompasses the inseparable relationship between peace, stability, democracy and good governance on one hand, and human rights and food security on the other (Conference of Ministers of Agriculture, Eastern and Southern Africa, p. 1)."

SAATS is complementary to and supportive of the priority areas of population and disaster mitigation. Improvements in agriculture will lead to increasing availability of nutritionally adequate food supplies at affordable prices. Nutritional adequacy is a fundamental requirement of a healthy population. Similarly, improvements in agriculture will lessen the impact of natural disasters such as drought. While not intended as disaster mitigation per se, SAATS will take a long-run perspective to alleviating underlying problems and consequently to mitigating the impact of natural disasters that affect the food and agricultural sector.

Past agricultural technology development and transfer activities faced an inhospitable relationship between agriculture and nonagriculture prior to structural adjustment. Incentives within the agricultural sector were hampered by overvalued exchange rates; monopolies in input and output markets, sometimes run by governments; and restrictions on producer prices or sales. Often there was an attempt to use administrative fiat to extract resources from agriculture to support nonagricultural activities. This forced extraction failed. Reasons for the failure are many; one of the most important is that farmers and herders had little incentive to adopt improved techniques or apply greater levels of inputs under the implicit taxation schemes that characterized much development planning.

Following structural adjustment, SAATS has the opportunity to work in a much more hospitable environment. It will improve upon the previous activities by using this environment to generate and disseminate sustainable techniques that will increase the income-generating opportunities in both the on-farm and off-farm sectors, taking full advantage of the synergies at work between these two sectors.

3.1. Statement of the problem

Increased production of food for the nonagricultural sector requires productivity improvement in both the on-farm and off-farm components of the food system. Improved productivity at the farm level is meaningless to the consumer if the food is not shipped to the consumer and if the increased farm-level productivity is not reflected in lower food prices. A necessary condition for agricultural transformation is increased productivity of the off-farm portion of the agricultural sector (processing, shipping, wholesaling and retailing, and preparation).

The problem with past agricultural technology development and transfer activities is that they have attempted to achieve economic development through increased farm profits, rather than through opportunities available between on-farm and off-farm income generating activities and between the agricultural and nonagricultural sectors.

Past agricultural technology development and transfer activities have been relatively ineffective in alleviating off-farm constraints to and encouraging off-farm opportunities for agricultural transformation. Considerable time and money has been devoted to improving on-farm productivity, with some notable successes (Oehmke and Crawford, Oehmke, Plucknett). While isolated efforts and successes have been achieved in improving off-farm productions, the overall neglect of this area has meant that conditions sufficient for agricultural transformation, most notably a greater ability in the economy to rely on markets rather than subsistence farming, have failed to be met. An examination of the performance of sub-Saharan agriculture over the past five years leads to the conclusion that "the need to exploit agriculture's growth linkages with the rest of the economy is even more urgent in 1994 than in 1989" (Cleaver and Donovan). The SAATS Initiative will improve upon the performance of past agricultural technology development and transfer activities to realize the full advantages of these linkages.

SAATS will encourage economic growth by capitalizing on synergies available between on-farm and off-farm activities and between the agricultural and nonagricultural sectors. The primary means of accomplishing this is through increases in agricultural productivity, particular in those critical areas in which linkages and synergies can be established. Three subsidiary issues need to be addressed: (1) determination of technical priorities, means of addressing them, and agricultural technology development and transfer outputs is not based on sound technical, social and economic analysis; (2) African national agricultural research systems lack established and sustainable institutional structures capable of addressing off-farm technical issues in a consistent and coherent manner that meets the demands of the clients; and (3) the lack of regional coordination and institutional capacity to coordinate agricultural technology development and transfer activities across national systems.

3.2. Goal and subgoal

The strategic goal for the SAATS Initiative is **sustainable, broad-based, and market-oriented economic growth.**

The close relationship between increases in aggregate measures of economic performance, such as gross national product (GNP) or per capita income, and indicators of individual welfare is well documented. For example, longevity rates, per capita food availability, and indicators of personal health are positively correlated with per-capita income. Child mortality, disease, and malnutrition are negatively correlated with income. Consequently, stimulating sustainable economic growth is likely to cause significant improvements in individual welfare.

Economic growth also contributes to broad social goals. For example, civil stability and the workings of democracy are facilitated when people have access to adequate employment or other income-generating opportunities. Increases in government revenues generated by growth allow investments in physical and social infrastructure, educational services, and other socially desirable activities.

The subgoal of the SAATS project is *increased contribution of the agricultural sector to sustained economic growth.* The importance of using agriculture to stimulate sustainable economic growth is summarized by Pinstrup-Andersen and Pandya-Lorch.

> Agricultural intensification addresses the root causes of poverty in many low-income developing countries: agriculture is the most viable lead sector for generating incomes and employment in both farm and nonfarm economies in most developing countries (Pinstrup-Andersen and Pandya-Lorch, p. 1).

SAATS argues that only those countries with an economy based on nonagricultural sectors—such as Botswana—have ever achieved rapid development without rapid agricultural growth. Most economies in sub-Saharan Africa are agriculturally based. The discussion in the development paradigm argues that for sub-Saharan Africa, agriculture is not just the most viable lead sector but that agricultural growth is a necessary precondition for broad-based economic growth in sub-Saharan Africa. It is clear that to contribute to broad-based growth, agriculture must not only grow at a sufficient rate but also must contribute to growth in the nonagricultural sectors.

3.3. Strategic objective

The strategic objective of the SAATS Initiative is *increased and sustained productivity of priority agricultural-and-natural-resource system products.*

There are two options for attaining rapid agricultural growth and increased contributions to nonagricultural growth: extensification onto new land, and productivity

increases through intensification. With a few exceptions, most of the arable land in sub-Saharan Africa is already employed in agriculture, and that which remains is largely fragile land that would be endangered by traditional agriculture. Large-scale extensification is not a sustainable option. Consequently, increased productivity is a necessary condition for rapid, sustainable, agricultural growth.

Productivity increases can stimulate agricultural growth and contributions to general economic growth in a fashion consistent with sustainable management of natural resources and with contributions to broader social goals. "Agricultural intensification holds great promise as an instrument to simultaneously alleviate poverty, meet food needs, and avoid exploitation of the natural resources" (Pinstrup-Andersen and Pandya-Lorch, p. 1). There is a bijective correspondence between intensification and technical change on the one hand and productivity increases on the other. SAATS will concentrate on productivity increases that are priorities for stimulating and sustaining agricultural transformation.

While there is a strong complementarity between technical change and intensification, SAATS will emphasize support for technical change and the institutions that generate such change. Such concentration offers the best opportunity to stimulate economic growth:

> Market linkages that connect a dynamic agricultural sector to rapidly growing industrial and service sectors offer an opportunity ... if both the agricultural and nonagricultural sectors are growing. An emphasis on finding the policy environment that creates such mutual growth is needed is needed. For agriculture, that environment must call forth rapid technical change. (Timmer, 1990, p. 58)

Institutional innovation will be used to develop African technology systems to the point where they can generate rapid and sustainable technical change.

3.4. Program outcomes

3.4.1. Program outcome 1

The first program outcome is *increased use of sustainable and profitable techniques.*

There are three direct and causal links between this program outcome and the strategic objective of increased and sustained productivity: (1) sustainable and profitable techniques are a direct cause of increased productivity, both on and off farm; (2) increased income from use of sustainable and profitable techniques stimulates additional investment in productive and income-generating activity; and (3) increased use of sustainable techniques reduces resource degradation through improved natural resource

management and through greater reliance on intensification rather than on extensification onto fragile lands.

Achievement of this outcome will be a direct result of achieving the remaining outcomes. SAATS activities in support of this outcome will be those activities directed toward achieving outcomes 2, 3, and 4.

3.4.2. Program outcome 2

The second program outcome is *increased availability of and access to profitable and sustainable technology.*

Increased productivity and increased use of sustainable and profitable techniques are directly dependent on availability of and access to those techniques. Availability means that the techniques are known to the technology system and implementable within the social and economic constraints of the region or country. Access means that farmers, processors, retailers and other users have the opportunity to purchase the input embodying the technique and/or acquire the knowledge to implement the improvement. Failure of either availability or access means a failure to generate the rapid technical change needed to achieve the strategic objective.

SAATS will achieve this program outcome by assisting regional and national agricultural technology development and transfer systems in making currently used techniques more accessible, by introducing known but unused techniques into the mix, and by developing additional improved techniques. The broad categories of techniques that will be made available and accessible include on-farm, off-farm and natural resource management techniques. As part of the empowerment of Africans, the specific techniques to be investigated should be determined by the African organizations. An example of an on-farm technique might be an improved plow that improves water retention in plowed soil and increases crop productivity; an example of an off-farm technique may be a new sisal product that increases the profitability of this crop when grown on marginal lands and provides increased employment in the processing sector.

3.4.3. Program outcome 3 and targets

The third program outcome is *strengthened human and institutional capacity for agriculture and natural resources technology systems.*

Agricultural transformation based on rapid technical change is a dynamic and continuing process. As the agricultural sector is transformed, continued research, development and transfer of new and increasingly innovative techniques and products is required. Current African technology systems are not yet capable of sustainable development and dissemination of profitable innovations on a continual, sustainable, and rapid basis. Additional human and institutional capacity is needed before the technology systems are proficient at making the needed techniques available and accessible.

SUSTAINABLE AFRICAN AGRICULTURAL TECHNOLOGY SYSTEMS

Sustained increases in productivity of profitable griculture and the natural resource products

INDICATORS
1) Productivity of key commodities and consumer goods

OUTCOME 1
Increased use of sustainable and profitable techniques.

ILLUSTRATIVE INDICATORS
1) Hectares under improve practices
2) Number of adopters
3) Profitability of adopted practices.
4) IMPROVED SUPPLY OF PRIMARY PRODUCTS & VALUE-ADDED PRODUCTS
5) INCREASED SUPPLY OF LOW-COST FOOD.

OUTCOME 2
Increased availability of, and access to, profitable and sustainable technology.

OUTCOME 3
Strengthen the institutional environment for agriculture and natural resources management Technology Development and Transfer.

OUTCOME 4
Advantageous policy and market environments for agricultural transformation in selected sub-sectors.

USAID
Africa Bureau (AFR/SD/PSGE)
Office of Sustainable Development
Productive Sector Growth and Environment Division

Strengthened human and institutional capacity is needed at both the regional and national levels. National technology systems are the primary means of making improved products and techniques available to users.

Critical areas for SAATS intervention to develop institutional capacity include establishment of regional coordinating mechanisms, acceptance and use within these mechanisms of protocols for harmonizing regional programs, founding of sustainable financing mechanisms, development of mechanisms for empowering users groups, institutionalizing strategic planning (including priority setting and impact assessment), design of mechanisms to facilitate postharvest technical work, and strengthening of linkages among components of the technology systems. Human capacity will be developed to initiate and sustain these institutional innovations; increased human capacity will also be developed in other biophysical and socioeconomic technical areas.

3.4.4. Program outcome 4 and targets

The fourth program outcome is *policy and market environments allowing for agricultural transformation in priority subsectors.*

While increased use of profitable and sustainable techniques is a necessary condition for increased productivity and agricultural transformation, it is not sufficient. Improved on-farm productivity does not lead to greater access of urban consumers to more affordable food if the policy or market environment fails to bring the food to the urban area, or does so only at a high price. Consequently, policy and market environments that allow for productivity increases in agriculture and for the translation of these increases into meaningful benefits for the nonagricultural sector are necessary conditions for transformation and economic growth.

While structural adjustment has made substantial progress in eliminating government interventions that were ineffective or worse, it has not replaced them with the legal and structural underpinnings necessary to facilitate a competitive market in technological outputs. For example, not all sub-Saharan African countries have adopted legal protection for intellectual property rights; those that have such legal protections also have untested enforcement mechanisms.

SAATS will undertake two activities critical to establishing a policy and market environment that allows for agricultural transformation: (1) it will support the inauguration and strengthening of regional, social science, collaborative research networks to provide analysis of national and regional policies and their effects on the technology system; and (2) it will constitute working groups on input distribution (including innovative techniques and products) to propose solutions to policy and marketing problems with the dissemination and distribution of technical innovations.

In defining this program outcome, considerable care was taken in choosing the phrase "policy and market" to reflect both public-sector (policy) and private-sector

(market) attitudes and actions that could influence the development, dissemination, or use of improved techniques. The composite of these attitudes and actions, the policy and market environment, will be harmonized, to the extent possible, with the efficient operating of the technology systems. This is not to say that subsidies or other financial support for technology external to the agricultural technology development and transfer system is needed: there is considerable doubt that subsidies are economically efficient (e.g., Howard for pricing subsidies in Zambia; Meyer on credit for agricultural inputs). The environment needs only "allow" for transformation by establishing a well-articulated set of ground rules that are reasonably neutral with respect to agricultural. A good example is the establishment of protection for intellectual property rights. The lack of rules for intellectual property rights protection prevents multinational companies from introducing their improved germplasm in African countries. The fear is that they will invest in physical plant, contacts, and personnel in a country, but that their varieties will be copied and they will not be able to recoup the cost of their investments. Stakeholders in Kenya cited this as a major reason why they could not get the best varieties for their horticultural crops. The result is lower yields and lower-quality fruits and vegetables. To remedy this, well-specified intellectual property rights protection is needed: this allows for introduction of improved varieties, but provides no subsidies or other incentives to introduce them other than what is available in the marketplace.

3.5 Targets and indicators for program outcomes

3.5.1. Targets and indicators for program outcome no. 1

Targets for this program outcome should reflect the diversity of African agriculture, the long-term nature of research and development (a minimum of ten years), and the short-term life of SAATS as a USAID project (now scheduled for five years). Even by targeting high-priority commodities, SAATS is unlikely to be able to influence the commodity subsectors that generate more than one third of agricultural gross domestic product. However, this creates a first target: that SAATS generate, disseminate, or transfer improved techniques in subsectors that cover at least one third of agricultural gross domestic product in each region.

Indicators of progress toward this outcome for individual techniques include number of adopters, the projected adoption ceiling or size of the target population for the particular technique (development of techniques serving a broader population are more likely to stimulate transformation), the proportion of the target population currently adopting, the intensity of adoption (e.g., fertilizer application rate or fraction of improved breed in total herd), the ceiling level of intensity, and the proportion of current-use intensity in the ceiling level (e.g., the current fertilizer application rate in sub-Saharan Africa of about 9 kg per ha is probably 10 percent of what could be applied sustainably and profitably, given the right enabling conditions).

SAATS will endeavor to bring multiple new techniques into use. An important criterion of impact on use and adoption is the number of producers (or consumers) who use at least one new technique (or product) on a regular basis. Users of multiple improvements (e.g., improved breeds and veterinary services) are likely to be well on their way toward increased productivity, if they have not already achieved substantial increases. Thus, a second important indicator for monitoring progress is the number of multiple-technique users, and the average number of improved techniques per adopter. Adoption ceilings and the proportion of the ceiling level currently adopting are also important indicators.

A concurrent target is the potential impact that these improved techniques have. These techniques should lead to a cost reduction of at least ten percent per year for three years, among adopters (or thirty percent for a single year). The three-year nature of this target reflects differences in the intensity of adoption. For example, a farmer may plant an improved variety on one third of her land as a test in the first year she tries the variety. If successful, she may increase the amount of land planted to this variety as well as the level of inputs applied, leading to successive reductions in the per-unit cost of production.

Alternatively, targets such as land productivity (10 percent increase for each of three years), labor productivity, multifactor-productivity, or export earnings could be used instead of per-unit cost reductions, depending on how the specific innovation is intended to further the strategic objective.

The improved techniques should also meet targets for sustainability. These targets are discussed in one of the technical specialist's reports (Mark Powell).

Targets for adoption are also important. Adoption and use of improved techniques usually follows an S-shaped (ogive) pattern with respect to time. In early years, only a few percent of the potential adopters will use the innovation. As time passes, adoption becomes more and more rapid, until most people are using the innovation and the number remaining to adopt dwindles. Consequently it is important to set targets both for the potential number of adopters and for annual adoption percentages. A fixed target for the potential number of adopters is inappropriate due to the diversity of African agriculture and the diversity of possible innovations; however, the potential number of adopters should be consistent with the GDP-target calculation. For example, suppose the maize subsector contributes one third of agricultural gross domestic product and a short-cycle, drought-resistant variety is introduced. This variety may be profitable only among smallholders on marginal lands, who contribute, say, one half of maize production. Then this varietal innovation would cover one sixth of agricultural gross domestic product, not one third, so additional innovations would be necessary to hit the one-third target. Then, adoption among the smallholders must start. One possible target is that within three years after release, 8 percent of the potential adopters are using the innovation. Based on previous experiences with adoption curves (e.g., Henry de Frahan, Boughton), this is suf

ficient to hold out the possibility of significant and rapid adoption by the majority of the target population in the succeeding five years.

3.5.2. Targets and idicators for program outcome 2

It is expected that at the end of the project there will be a greater number of techniques to select from in priority areas. These techniques may be improved methods for growing or processing agricultural outputs, or they may be embodied in improved-quality inputs or outputs. Currently known techniques will be available from a wider variety of sources, providing greater geographic and demographic coverage of the market; techniques currently in use will be made available at lower real prices. The availability will be commensurate with covering commodity subsectors contributing one third of agricultural gross domestic procuct, as discussed above.

Specific indicators for monitoring progress will depend on the priority areas chosen. General principles to be followed are that the criteria include the number of techniques among which demanders can choose; the ease of adoption of these techniques; and the pecuniary and nonpecuniary costs of obtaining the inputs necessary to adopt the technique. For example, maize breeders may develop six short-cycle varieties suitable for drier, marginal areas; these varieties may be easy to adopt in that they do not require changes in the traditional planting or harvesting routines; but if the varieties are available only in the large cities then access is limited. Similarly, improved consumer products are only as accessible as the nearest store or retail outlet carrying such products.

Some general guidelines can be thought about. Each of the innovative techniques or products developed and disseminated should be available in stores, retail markets, or other outlets visited at least once a year by 80 percent of the target population (potential adopters). The real price of improvements embodied in purchased inputs, such as hybrid seeds, shall have declined (measured as same-store sales).

In addition, SAATS must look continually to generate additional innovations for dissemination after the life of the project. At the end of the project, potential innovations covering another one third of agricultural gross domestic product should be in the screening and testing stage, with projected dates of release within five years of the end-of-project.

3.5.3. Program outcome 3

The initial focus of the strengthening activities is on the empowerment of Africans in harmonized, regional, agricultural technology development and transfer priority-setting. Indicators that this has happened include: (1) an established regional agricultural technology development and transfer body with predominantly African membership, (2) established criteria/voting rules in the body for selection of agricultural technology development and transfer priorities, and (3) allocation of funds based on the selected priorities. The first two indicators are yes/no and the target is an affirmative answer. The third

indicator could be measured as the percentage of available funds allocated via the priority-setting mechanism. Allocation of 75 percent of the funds to selected priorities after five years is sufficient to move the agricultural technology development and transfer agenda forward, yet allows flexibility to invest in secretariats, special activities, and other areas necessary for the smooth functioning of the regional body.

The key targets to be achieved are legal incorporation; certification to receive funds; adequate representation of national interests in the organization; adequate representation of private-sector interests in the organization; endorsement by the organization of guidelines for information to be used in cross-commodity and within-commodity priority setting for technical and programmatic activities, based on economic, social, and technical analysis; endorsement of protocols for actually making the priority-setting decisions; protocols for determining which regional training, technical assistance, and other activities for strengthening national institutions are to be supported, and to what extent; implementation of monitoring and evaluation procedures, implementation of accounting procedures for financial management, and implementation of procedures supporting eventual impact assessment.

3.5.4. Program outcome 4

Specific targets are not available until analysis of particular constraints is completed. General targets include policy and market-constraint analysis, specification of policy modifications, and implementation of the modified policies.

4. Plan of action

The types of regional and subregional actions that SAATS will support, fall into four categories:

i. establish regional coordinating mechanisms, including development of sustainable financing plans and mechanisms for collaborative regional programs that will increase national system governance and management of regional programs;
ii. strengthen regional and national institutions through institutional innovation;
iii. regional and national research, development and transfer activities to increase the flow and use of technology; including support for extant regional networks currently funded under PARTS, that are functioning effectively.
iv. cross-regional actions that are of benefit to national systems in different parts of the contintent.

In the course of implementation the types of activities noted above will be complementary and interdependent, especially instutional innovation and support for technical research, development and transfer. SAATS will launch a new approach to providing assistance in the area of agricultural technology development and transfer that builds on the synergy between institutional and technical development activities. It will promote this synergy by requiring (a) broad stakeholder participation and representation in governance, (b) stakeholders make their institutions accountable for development impact, (c) that there are transparent, technically sound critiera and processes to focus and concentrate on high priorities, and (d) there are resources and mechanisms in place to enable the technical research and development to take place. SAATS will move USAID and other donors away from prescribing priorities, apriori, and move them toward working with and through the principal stakeholders to build coalitions around priorities that the stakeholders have ownership of; and technical support institutions accountiable to their stakeholders to address these priorities.

Realizing that this is an ambitious new way of doing business, some transition will be needed to (a) shift current well functioning technical activities to this new mode, (b) sustain momentum and increase efforts to raise productivity, and (c) ensure national and regional institutions can perform the necessary functions to gain the trust of stakeholders, including funding agents.

4.1. Regional coordinating mechanisms

SAATS will help establish and strengthen regional coordinating mechanisms to promote and support governance that increases the role and responsibility of leaders of national technology systems (public and private) for regional programs. The increased attention to improved governance reflects an evolution of current regional and national programs to be more responsive to local stakeholders. The restructured or newly established regional

coordinating mechanisms build on successes of past regional programs and the improved human resource capacity in African technology systems that has been developed over the past two decades. The principal mandate of the regional coordinating mechanisms is to facilitate a focussing and concentration of effort on regional themes and commodities that are a priority across the region (in two or more countries). The regional coordinating mechanisms will improve donor coordination and continuity for priority programs. The coordinating mechanism will also provide a vehicle for sharing of experience and lessons from bilateral and national assistance within the subregions and, thereby, increase the value of bilateral assistance.

The need for the coordinating mechanisms has been established through joint actions taken by ministers of agriculture and heads of state for East and Southern Africa as well as for West and Central Africa.

The principles underlying the formation of these organizations have been developed collaboratively in East and West Africa through the Special Program for African Agricultural Research "Framework for Action" initiative. In Southern Africa, the Southern African Center for Coordination of Agricultural Research and Training was created through joint national and donor action in the mid 1980s. The Special Program for African Agricultural Research initiative has involved numerous substantive consultations among national research system leaders and policy makers, regional and international organizations, as well as donors and other funding agents in East, West, and Southern Africa.

Actions taken under the SAATS Initiative emphasize the use of African-led regional organizations to promote coordination across commodity or thematic regional programs and collaboration among countries within a region, e.g., East, West, Southern Africa. In East Africa, the newly formed Association for Support of Agricultural Research in East and Central Africa (ASARECA) is the relevant organization. In West Africa, progress in the development of the regional coordinating mechanism is less advanced. Proposals call for two subregional coordinating organizations, one for the arid zone (CILSS countries of the Sahel), and a second for the more humid coastal zone of West and Central Africa. However, experience of the past decade has demonstrated that in West Africa it is imperative to strengthen collaboration among the coastal and Sahel countries. Recognizing this imperative, Special Program for African Agricultural Research organizers hope to form a consortium to integrate the regional organizations into a single coordination mechanism for West and Central Africa in the near future. In Southern Africa, the Southern African Center for Coordinating Agricultural Research and Training is the relevant organization.

Table 6. Regional coordinating mechnisms

Organization	Members	Headquarters
Southern African Center for Coordination of Agricultural Research and Training (SACCAR)	Botswana, Lesotho, Swaziland, Zimbabwe, Republic of South Africa, Tanzania, Mozambique, Namibia, Zambia, Malawi	Botswana
Association for Agricultural Research in East and Central Africa (ASARECA)	Kenya, Uganda, Ethiopia, Madagascar, Burundi, Rwanda, Sudan, Eriteria, Djibouti, Tanzania, Zaire	Uganda
West and Central Africa	Sahel and Coastal countries	TBD

SAATS will concentrate attention on East and West African regional organizations. Southern African Center for Coordination of Agricultural Research and Training is established and it is recommended that support to strengthen the SADC FANR sector institutions be provided by the initiative for Southern Africa. SAATS Actions and their sequencing for establishing regional coordinating mechanisms in East and West Africa are shown in Table 7.

There are two critical areas for SAATS action in building the regional organizations, and in turn the coordinating mechanisms:

i. Assist national leaders create the regional coordinating mechanism and governance structure; and
ii. Assist the regional umbrella organizations develop a secretariat that will assist the governing body with analysis for and coodination of the priority-setting process and a mechanism for allocating funds in line with established priorities.

Table 7. Summary of SAATS activities to establish regional coordinating mechanisms

Activity	Date Initiated	Duration or Date Completed
Establish West Africa Regional Coordinating Mechanisms		
Establish East Africa Regional Coordinating Mechanisms		
Establish Southern Africa Regional Coordinating Mechanisms		

The functions of the regional organization, among other things, will include: (see Association for Strengthening Agricultural Research in East and Central Africa, the Southern African Center for Coordination of Agricultural Research and Training and regionalization in WCA meeting minutes).

- provide a forum for the identification of regional priorities across commodities and themes,
- provide a forum for the coordination of efforts among countries on topics, commodities and themes of common interest,
- coordinate support support for priority programs,

The regional coordinating mechanism is an umbrella organization with the following characteristics:

- Members include the Directors of the National Agricultural Research Systems
- Membership or other representation is provided for other participants and institutions in the national and regional agricultural technology system.
- The organization has legal incorporation and donor certification to receive and disburse monies.
- Has links with the priciples developed through the Special Program for African Agricultural Research consultative process as expressed in the frameworks for action.
- Has a mechanism for sustainable funding and is developing the necessary financial resources.
- Has a transparent mechanism for setting priority areas for technical and institutional support based on sound economic, social (including environmental) and technical analysis, and consistent with expressed national priorities.
- Responds to requests from national systems and their consituents for assistance with technological and institutional innovation in specified priority areas.

- Has contractual mechanisms and flexibility to subcontract with the full range of participants in national, regional and global technology systems, to provide or contract for the highest-quality assistance at the lowest cost.
- Leverages funds behind priority areas and actions.

Increasing goverance and coordination of regional programs fundamentally implies that the governing group has authority over the resources available to support the research and development activities that it has responsibility to coordinate. Placing resources at the disposal of the coordinating mechanisim or governing group will require confidence on the part of funding agents that resources will be used wisely to address strategic development issues. A critical concern is strategic planning. To be effective, regional research organizations should be able to make three strategic-planning decisions:

i. which commodity subsectors have the greatest potential to generate impact,

ii. what constraints and opportunities exist within the commodity subsector, and

iii. how best to alleviate constraints and advance opportunities, including a determination of whether a technical approach is the best approach, and if so, who is the best person/institutions to implement that approach.

These determinations should be based on transparent and meaningful criteria, and funding should be allocated in accordance with such determinations. Failure to address these issues or to allocate resources accordingly would suggest that research was being conducted in a somewhat haphazard fashion, and would be grounds for ceasing regional activities under the SAATS Initiative.

SAATS will support the strategic planning process, priority setting and impact assessment; and, will support efforts to strengthen regional organizations by assisting with the development of sustainable financing plans and mechanisms (see section 4.2). SAATS will also provide support for technical research, development and transfer activities (see section 4.3).

4.2. Support for institutional innovation

The activities will help establish a sustainable institutional framework for collaboration among countries on technology development and transfer issues in agriculture and natural resource management. SAATS supported activities will strengthen and harmonize the linkages between national, regional and international research and development organizations in support of national development goals.

While the strengthening of regional organizations to support collaboration and coordination is an innovation of a high order in its own right, additional strengthening is needed if the institutions are to remain viable into the twnety-first century. Five

innovations will be introduced to strengthen the institutional structure and stability of the regional and national organizations:

i. building coalitions of support groups,

ii. building capacity to respond to evolving client needs in a timely fashion,

iii. establish sustainable financing plans and mechanisms,

iv. establish strategic planning, priority setting and impact assessment systems.

v. protocols to harmonize the organization, planning and management of collaborative regional research programs.

The regional coordinating mechanism/group will be responsible for selecting implementing agents, including national and international groups to facilitate implementation. Until the regional organizations are incorporated and certified, SAATS will consider innovative systems to channel financial and technical support to the regional coordinating organizations, regional programs and national organizations to support institutional innovation. One possibility is to provide funds through the Special Program for African Agricultural Research Secretariat.

4.2.1. Building coalitions for support

The principal clients of the regional organisation are the national technology systems, and their participants, component institutions, and constituents. These clients are the likely support groups. Such clients can be powerful lobbyists for continuation and augmentation of the regional organization. Building a coalition means working with and through these clients to develop the political and economic support necessary for institutional sustainability.

National systems need to build coalitions for support in a similar fashion. National institutions with political and economic backing will be more sustainable as institutions, and will be better placed politically to support regional activities and institutions complementary to national objectives.

To assist with the coalition building, SAATS will provide support for the following activities:

1. a subregional stakeholder meeting representing a broad cross section of interests in the subregion that leads to the development of protocols at the national and regional level on governance and exchange of technologies regionally,

2. national stakeholder meetings, linked to the above subregional meeting, that involve a broad cross section of stakeholders to build a coalition of support for regional activities at the national level,

At present regional organizations supporting technology development and transfer do not include full representation of the private sector and other users groups in the decision making process. And the political will to support regional programs is not embedded in the general populus of the Agriculture and natural resources sector at the national level. To be sustainable the political will and representation need to be fully addressed and integrated into the regional programs. An outline for institutional reform to provide this representation was provided in section 1.5.

The stakeholder meetings will also help provide guidance on the governance structure for sustainable funding mechanisms, such as an endowment. The Board of Governors of an endowment would normally be chosen from a cross-section of society, including private sector and other user groups. Rules of selection to the board of governors could be reviewed at a stakeholders meeting. This action would help broaden the influence of the regional coordinating mechanism as well as develop linkages with local non governmental sources of funding.

To support these activities, a trust fund will be established at the Special Program for African Agricultural Research Secretariat to support coalition building.

4.2.2. Building capacity to respond to evolving needs

An ongoing, developing relationship between the regional organization and client groups depends on the regional organization being able to change and develop as client needs change and develop. A static institution will outlive is usefulness, and eventually decay. The strength and creativity of the regional and national institutions to a large extent rest in their human capital. To build capacity, SAATS will provide support for the following activities capacity:

1. short-term training, including fellowships and sabbaticals, to support the retraining or more specialized training for technical and social scientists, research administrators, financial management speicalists, communication specialists.

2. support to establish a protocol among universities within a subregion to facilitate exchange of students and increase access to higher degree training in Agriculture and natural resources, to include communications, publications, linking with different groups, human resource development.

4.2.3. Sustainable financing plans and funding mechanisms

SAATS will support efforts to develop stable, sustainable funding for programs and support services that provide the long-term foundations for sustainable development. Activities that will be supported in this regard include:

1. feasibility studies for regional coordinating organizations for sustainable financing plans and mechanisms,

2. feasibility studies for national institutions for sustainable financing plans and mechanisms, that include identification of reforms and actions needed to increase national funding;

3. support to establish a regional task force on sustainable financing;

4. seed funds to establish regional endowments for collaborative regional research programs.

In support of efforts to establish the regional coordinating mechanism, SAATS will provide assistance for the development of sustainable financing plans and funding mechanisms for the regional coordinating institutions. SAATS will fund a contract to help each of the regional coordinating agencies study and implement the most promising of the sustainable funding alternatives. This will include a close examination of national funding sources that will need to be made available to support the regional efforts. Endowments or foundations appear to be the most appropriate nontraditional funding sources for regional organizations. An endowment could accept funds from a broad range of funding soures as well as from different donor programs. It would provide a means of managing the capital to provide stable long-term resource flows to complement other available funding sources. This work should build on the accumulated experience of the Africa Bureau's Sustainable Financing Initiative. By year three of SAATS it is expected that all support for technical research and development activities will come from the regional endowments for technology development and transfer.

SAATS will also provide support for national feasibility studies on sustainable financing, based on the explicit written demand from the national institution's parent organization or governing board. SAATS will not provide funding for national endowments per se, but will assist with the planning and sharing of experience from within the region on these development issues.

4.2.4. Strategic planning, priority setting and impact assessment

At the heart of the reform agenda for national and regional technology organizations is the need for strategic plans, priority setting, and impact assessment. Experience from past efforts to establish strategic or master plans indicates that concerns for these can not be

simply addressed by one-off studies, but rather require the establishment of a coalition building process that links analysis with policy formulation and strategy development.

To support strategic planning, priority setting and impact assessment SAATS will help establish a Social Science and Policy Analysis activity. The SSPA activity will take the form of a collaborative research network.

The headquarters for the SSPA network will be located in the secretariat of the regional organization/coordinating mechanism. The network will provide input to the Board of Directors for the coordinating mechanism. One option is to establish the headquarters at the secretariat of the regional coordinating organization. Regardless of where the headquarters is located, it should have strong linkages to the coordinating mechanism and governing group. This will help ensure linkages with policy formulation and strategy design.

The social science and policy research will be completed by network members that will include national, regional and international institutions. The network responsibilities will be (1) to respond to priority-setting needs at the regional level, (2) to facilitate development of socioeconomic units within the national agricultural research systems, including social science sensitization workshops, training workshops, and a small amount of technical assistance, and (3) develop plans to respond to further needs of the regional and national organizations with respect to social science activities.

4.2.4.1. Strategic planning

The initial social-science activity will be to undertake strategic planning in the regional organization and to facilitate strategic planning in the national systems. The social-science network shall work to identify priority subsectors, constraints and opportunities within these subsectors, and methods and procedures for alleviating constraints and capitalizing on opportunities. As agriculture changes, so too may these priorities. Thus, strategic planning is an ongoing process.

Human and institutional capacity will need to be established at the national and regional levels for determination of which commodity subsectors have the greatest potential to generate impact and for determining constraints and opportunities in the priority subsectors. Investigation methods germane to these processes include cross-commodity priority setting, commodity subsector studies, and industry analyses, respectively. The subsector and industry studies together should define potential actions for tailoring policies or technologies to address the priority at hand. They should also specify the appropriate level at which the action is to be undertaken: national, regional, or international.

Given the limited human resources in policy analysis, it will likely be beyond the capacity of the SSPA network to carry out the full complement of sectoral, sub-sectoral and industry analyses. The SSPA will establish subcontracts where necessary. It will use

these subcontracts to engage public and private research centers within the subregion in a way that generates the necessary results while building national capacity.

4.2.4.2. Impact assessment

The SSPA network will assist national and regional programs assess the impact their research and development efforts. The impact assessment activities will:

1. develop improved impact assessment methods to allow greater accountability, and better targeting of investments in agricultural technology development and transfer;
2. help researchers institutionalize impact assessment, through training and institutional support activities; and
3. support the regionalization of research activities to expand communication among African scientists and cooperation among national programs.

4.2.3.3. Further SSPA activities

The SSPA network should form an agenda to respond to priorities of the regional organization and to requests for support in these priority areas by the national systems. The particular areas of investigation will vary by region and by the needs of the national agricultural research systems. Some examples include:

- Priority-setting, monitoring and evaluation, and impact assessment. Sensitization, training, and backstopping at the national and regional levels.

- Policy Analysis. Social and economic analysis of macroeconomic, agricultural, price, and marketing policies, with emphasis on the relationships between technology and agricultural transformation.

- Food Security, and Drought and Disaster Relief. Defining the role of strategically oriented technology systems in strategic and tactical responses to such crises.

- Rural Infrastructure and Enterprise Development. Analysis of options for improving the impact of investments in rural infrastructure on rural and smallholder supply response; relationships between access to infrastructure and technical progress; relationships between infrastructure, demand for farm products, and rural sources of nonagricultural employment..

- Technology and Intellectual Property Support. Analysis of options for developing coalitions of farmers, processers, markets and other technology-users' groups to support national and regional activities. Analysis of impacts of different methods for protecting intellectual property; implications for public and private sector investments in agricultural technology development and transfer.

- International Shared Resources. Analysis of options to reach consensus regarding use of internationally shared bodies of water and other resources; implications for agricultural technology development and transfer.

While the list of options is long, not all can be covered by a fledgling SSPA network. Priorities within this network will need to be set by the regional coordinating organization in conjunction with stakeholders.

4.2.5. Harmonizing regional research programs

Regional programs currently operate based on the the institutional culture of the implementing institution, whose headquarters is often in another continent. These programs place an undue burden on the already weak national systems to adjust their systems for planning, resource allocation, organization, and management.

To harmonize regional programs and thereby reduce the pressure on national systems, two actions will be supported:

1. a protocol will be established providing guidelines for organization and management of regional programs operating in the subregion.

2. protocols will be established for each regional program among the national agents that are members of the program to clarify the role and commitment of member national and international agents.

A study will be completed in each subregion to guide the development of an umbrella protocol for regional collaborative networks. The protocol will develop an approach to regional collaboration adapted to the region and national systems' needs and capacity. It will build on the best practices of existing programs and provide the guidance for organization, management, planning and resource allocation of the high priority regional research and development programs that will receive support. The protocol will develop the framework for harmonization of regional programs.

Table 8: SAATS activities to support institutional innovation

Building coalitions

Activity	Date Initiated	Duration or Date Completed
West Africa Regional Governance Development and Protocol		
West Africa National Stakeholder Development		
East Africa Regional Protocol		
East Africa National Stakeholder Development		

Building capacity

Activity	Date Initiated	Duration or Date Completed
Short-term specialist training (1 person per country per year)		
West Africa Protocol for Training and Exchange of Scientific Personnel		
East Africa Protocol for Training and Exchange of Scientific Personnel		

Sustainable financing plans and funding

Activity	Date Initiated	Duration or Date Completed
West Africa Regional Endowment to Support Research, Development and Technology Transfer		
East Africa Regional Endowment to Support Research , Development and Technology Transfer		
Task Force and Feasibility Studies for Sustainable Financing		

Strategic planning, priority setting, and impact assessment

Activity	Date Initiated	Duration or Date Completed
East Africa Social Science and Policy Analysis Network		
West Africa Policy Analysis Network		

Harmonizing regional research programs

Activity	Date Initiated	Duration or Date Completed
Protocols on Regional Programs		

4.3. Support for research, development, and transfer

Through support for technical research, development and transfer activities SAATS, will contribute to the increased availability, access and use of profitable and sustainable technology. In the short term, three new sets of activities will be supported. It is anticipated that additional technical research, development and transfer activities will receive SAATS support based on the outcome of strategic planning, priority setting, and institutional innovation activities that will be completed in the first two years. The new activities that will receive immediate support reflect the opportunities to get substantial increases in output based on past investments, and reflect signifiicant gaps in the regional and national technology systems. In addition to new technical programs, SAATS will provide support for the continuity of ongoing programs that are performing well (see section 4.3.4) and have concurrance of the regional coordinating group. The technical activities that will receive SAATS support in the short term include four sets of activities:

1. Food and Post Harvest Technology Collaborative Regional Research Activities;

2. Transfer of Existing New Inputs and Techniques;

3. Natural Resource Management Working Group; and

4. Ongoing, well functioning, Regional Networks.

As the regional coordinating group develop strategic plans and regional priorities additional support will be provided. Depending on the availability of funds, SAATS will provide support for new programs beginning in year two and three of SAATS. It is

anticipated that some of the ongoing programs will be phased out. The specifics of such support will depend on the commodity and constraint or opportunity under investigation. SAATS will endeavor to be flexible in furthering African responsibility and authority to designate priorities for donor support by transparent and relevant priority-setting mechanisms.

SAATS will work with national, regional and international decision makers to establish criteria for identifying priority subsectors and opportunities that include instances where:

1. a modest amount of research will substantially increase the chances of a sustainable economic development impact in 3 to 5 years,
2. there is scientific promise that the research findings will enhance the likelihood of a profitable economic development impact and,
3. the risk involved in committing resources to utilize the new technique or product are acceptable to the entrepreneurs involved.

Indicators, such as the following, will be promoted to help select among priority industries:

1. expected rate of return on investment,
2. probability of research outcomes that will resolve obstacles to economic development investments, and
3. probability that these commercial ventures will be sufficiently profitable to be sustainable.

Industries considered will include ones established in other parts of the world, e.g., sweeteners from maize, and nontraditional industries, e.g., manufacturing newsprint from Kenf.

4.3.1. Creating a postharvest technology working group

The action in the food and postharvest area is to establish and support a working group. A working group rather than a network is the appropriate structure for activities in the food and postharvest technology area. This activity will increase attention to off farm issues. Increased use of the technologies will directly lead to increased jobs, especially in rural areas. This activity was identified as a high priority concern of stakeholders throughout Africa.

As one moves through the commodity subsector from farm-level production of raw agricultural commodities to refined and processed consumer goods, the number of products available tends to increase exponentially. Due to the diverse nature and large number of postharvest products, the number of actors involved and the diversity of their interests is also large. A network in this area is difficult to manage and may easily lose its focus on the problem at hand. A working group can identigy priority constraints,

opportunities, and products in the postharvest arena. It will not undertake the necessary research, development and transfer to alleviate constraints. Rather, it will identify key individuals, institutions, corporations, associations or other agents who may have comparative advantage in accomplishing the task at hand.

The working group will be headquartered in the regional secretariat. It will work with the secretariat to make funding available on a competitive grant basis for agricultural technology development and transfer activities in priority areas, as determined by the regional organization in conjunction with stakeholders. The working group will solicit proposals in priority areas; evaluate proposals, including the capacity of the investigators to disseminate findings; and provide funding to the chosen activities. They will report results to the regional organization, and make recommendations about current and future priorities.

4.3.2. Support for transfer of existing and new inputs and techniques

Regional coordination of the transfer of inputs and techniques can improve the access to technology by improving the quality and timeliness of materials used throughout the region. The critical inputs for on-farm production are planting material and fertilizer for crops, and improved-breed animals for livestock.

The SAATS action would be to help create and support a working group on technology transfer at the regional level. This group is not intended as a distribution mechanism or disbursement of credit activity. However, there are numerous actions that could be taken to improve the existing input distribution systems or the environment in which they work. These actions include:

- Analysis and harmonization of IPR protection.
- Harmonization and coordination of seed certification, including phytosanitary analysis.
- Analysis of economies of scale in fertilizer purchase and distribution.
- Facilitating transfer of planting materials across national boundaries.
- Facilitating transfer to farmers.
- Exchange of information about the effectiveness of and potential demand for specific planting materials, to facilitate timely delivery of adequate supplies.
- Link existing research groups that lack the mandate or capacity for transfer, such as the CRSPs, with appropriate transfer institutions.
- Link existing transfer organizations that lack the mandate or capacity for research, such as some nongovernmental organizations, with appropriate research and development institutions.

The diversity of these actions and the skills required to implement them successfully forms the basis for establishing a working group and not a network. The working group will provide assistance in these and other areas at the request of national agricultural research systems. Much of the assistance may be in the form of subcontracts

with private-sector groups such as nongovernmental organizations, or consultants. Contracts and subcontracts should be awarded on a competitive basis, where the evaluation looks not just at the cost of completing the activity, but also the quality of the service.

4.3.3. Natural resource management working group

SAATS support for natural resource management technology development will expand the natural resource management options of farmers and herders—who ultimately manage most of the land and much of the water in Africa.

SAATS will support innovative activities to promote improved techniqes that simultaneously further environmental protection through alleviating natural resource problems and degradation and promote agricultural transformation. The critical idea here has been posited by the White House for the United States—environmental management and job creation are complementary, not competitive. Fostering this creativity relies on environmentally stabilizing technical innovation. Within the African context, the natural resource management practices cited as paragons usually if not always rely on technical innovation. For example, water harvesting techniques usually rely on an innovative ridging or bunding technique, which requires labor to construct and maintain. Terracing to reduce soil runoff on hillsides, even when accomplished largely through agroforestry, requires innovation in land-management techniques, improved forestry inputs, and lots of labor. Innovation is the mission of technology systems. Consequently, SAATS will take a proactive role as a catalyst for removing the antagonism between agricultural and natural resources, and for reforming technology systems so that they create improved resource management techniques that nurture agricultural transformation.

The principal natural resource management activity that SAATS will support is an natural resources management working group. The working group will consist of members of existing regional programs (typicallly commodity programs) and nongovernmental organizations promoting natural resource management techniques. The working group will be given resources to increase attention given to natural resource management issues by the existing programs. The working group will identify key individuals, institutions, associations or other agents who may have comparative advantage in accomplishing the task at hand.

Past experience has shown that natural resource management activities separate from commodity-oriented research have little effect on agricultural productivity. The critical linkage to make is between natural resource management and commodity-oriented innovation that is directed toward productivity increases. The working group will facilitate the consideration of natural resource issues in commodity-oriented networks and programs by facilitating discussion and interaction among these networks and programs and the relevant national and ecoregional natural resource management activities. This will be accomplished by providing financial resources to commodity-based agricultural technology development and transfer activities to bring natural resource management

experts into the program as collaborators, and by providing forums for discussion among ecoregionally based natural resource management scientist and scientists working in commodity-oriented programs. Funding will also be made available to ecoregional natural resource management groups to bring in commodity and product specialists to introduce productivity-increasing products and techniques into the natural resource management research agenda.

Disbursement of funds would be through a competitive bid process, at the request of the national institutions or the regional networks in conjunction with the appropriate national institutions. Those commodities or themes most likely to stimulate agricultural transformation would be given priority.

The agricultural techniques and products developed through SAATS funding will be required not to diminish the potential of the natural resource base. This is part of the idea of sustainable technology systems: that such systems help to sustain the natural resource base.

Moreover, the techniques and products transferred will increase farm-level productivity. In addition to slowing extensification, increases in productivity make current resources more valuable. Thus, farmers and herders will have greater incentive to make investments in protecting those resources. For example, the yield response of improved varieties is often sufficient to make investments in ridging or other water-harvesting techniques profitable to the farmer; with traditional varieties, these natural resource management management techniques might not be used.

SAATS funded activities will promote greater involvement and empowerment of farmers, herdsmen and villagers in setting agricultural technology development and transfer agendas and in natural resources planning and management.

4.4. Ensuring continuity of functioning programs

The PARTS Project supports seven regional research networks: three in West Africa and four in East Africa. As the regional organizations mature, support for these activities is expected to come directly from them. Until such time as regional organizations are instituted, certified, and funded, it is important to provide transitional funding to those networks that are functioning efficiently and effectively.

SAATS will take advantage of the accomplishments of past investments in the PARTS-financed networks, both those accomplishments of a technical nature and those made in devolving control of the networks to Africans. The regional coordinating organizations are not yet ready to receive funds and take over coordination of these networks. To avoid their demise because of this logistical disjunction, SAATS should consider providing limited funding for networks through the existing financial and management mechanisms. SAATS funding provided directly to the well functioning networks would

decline each year during a three-year transition period. Each year during this transition, the networks would have to look to the regional coordinating organization for an increasing share of their financial support. After three years, direct funding for the international agricultural research center linked networks from SAATS would be eliminated. Network continuation after the transition would depend on the priorities and allocation decisions made by the regional coordinating organization.

A memorandum of understanding between AFR and Global (previously R&D) posits criteria for the support of research networks that would be funded by the PARTS project. The criteria have two nuances: first, that a commodity perspective be employed; and second, that a classification of research themes by potential be available and used in determining network actions. The memorandum was intended to cover a three-year transitional period.

It is expected that the SAATS Initiative will pick up continued funding for those networks that have met the criteria outlined in the memorandum. An early action of SAATS is to determine, jointly with the national research system directors, which networks have met the criteria and justify continued support. Until such time as the regional organizations are certified and financially solvent, support for networks meeting the criteria should be channeled through the relevant international agricultural research centers. This may require providing funding, on a declining basis, for a further, three-year, transitional period.

During the assessment of the current networks it is recommended that the performance criteria contained in the memorandum of understanding be modified. In particular, in the first criterion, "treat research themes" should be replaced with "generate research output"; in the second criterion, "have elements and conditions to facilitate" should be replaced with "generate"; in the third criterion "are designed to" should be stricken; and the last criterion should be replaced with "disseminate knowledge and transfer techniques." These changes reflect the natural progression of the networks from the design stage through implementation and generation of results.

Table 9. Summary of SAATS Activities for research, development, and transfer

West Africa

Activity	Date Initiated	Duration or Date Completed
Food and Postharvest Technology Collaborative Regional Program		
Natural Resources Management Working Group		
Technology Transfer Small Grants Program		
Rice Task Forces (subject to review and concurrence of national agricultural research systems)		
Maize Network (subject to review and concurrence of national research systems)		
Sorghum Network/Pole (subject to review and concurrance of national agricultural research systems)		
Program Support for Regional Technical Research and Development Activities.		

East Africa

Activity	Date Initiated	Duration or Date Completed
Food and Postharvest Technology Collaborative Regional Program		
Technology Transfer Small Grants		
Potato and Sweet Potato Network (subject to review and national agricultural research systems concurrence)		
Beans Network (subject to review and national agricultural research systems concurrence)		
Cassava Network (subject to review and national agricultural research systems concurrence)		
Agroforestry Network (subject to review and national agricultural research systems concurrance)		
Program Support for Regional Technical Research and Development Activities		

4.4.1. Cross-regional activities

SAATS will provide funding for cross regional activities that incude:

1. Support for Special Program for African Agricultural Research to strengthen donor coordination and support policy dialogue on strategic agricultural technology development and transfer development issues.

2. Industry Analyses to improve knowledge of technical opportunities across regions and outside of Africa, and

3. Improved electronic communications among national agricultural research systems and other members of the international research community.

4.4.2. Support for special program for African agricultural research

Support for the Special Program for African Agricultural Research (SPAAR) will improve the linkages with the international community supporting agricultural technology development and transfer. SAATS funding of Special Program for African Agricultural Research will focus on

1. backstopping regional organizations, especially during the transiton phase while the regional coordinating mechanisms and endowments are being established.

2. providing fora for analytically based policy dialogue on issues related to technology development and transfer in sub-Saharan Africa.

3. donor coordination to revitalize African agricultural research.

Over the past three years Special Program for African Agricultural Research has proven to be highly effective at working with leaders throughout Africa to bring an African perspective to the institutional constraints limiting technology development and transfer in Africa. Special Program for African Agricultural Research has also effectively engaged both donors and national leaders in identifying options and hard choices to build sustainable systems for the future. The Special Program for African Agricultural Research Secretariat, located in the World Bank, has built broad consensus around some key principles for the reform of national and regional technology systems in Africa. The Special Program for African Agricultural Research Secretariat will provide a critical link between SAATS and regional organizations that will provide the secretariats for the regional coordinating mechanisms. Working through Special Program for African Agricultural Research, SAATS will seek to develop broad donor and national system consensus around the SAATS development paradigm and the regional coordinating mechanisms, which are the fundamental underpinning of SAATS.

In the early period of SAATS, the Special Program for African Agricultural Research Secretariat will backstop the regional organizations through short-term technical support, where appropriate, to help develop terms of reference and plans of action for the coodinating mechanism. Special Program for African Agricultural Research will also coordinate donor support for key policy issues that need futher anlaytical attention to develop suitable guidance. In line with Special Program for African Agricultural Researchs mandate, they will bring donors, technical agents, and national policy makers

together to bridge the gap between analysis and policy formulation. These efforts will ensure effective coordination among principal support groups engaged in the revitalization of technology development and transfer in Africa.

4.4.3. Industry analyses

The initial cross-regional action supported by SAATS is selected industry analysis. Creating capacity for industry analysis in the national agricultural research systems or regional organizations is inefficient. Many areas ripe for industry analysis cut across regions, such as use of maize for new (to Africa) products such as sweetners, petrol additives, or breakfast cereals. In addition, it is important to the rapid generation of impact that a few, key, industry analyses be completed in a short time frame, and there is concern that establishing institutional capacity to do such studies in national agricultural research institutes or host-country universities will lead to lengthy academic studies of little practical use. Comparative advantage in doing such studies often lies with a private-sector association. Consequently the industry studies should be contracted and let for bid or run via a competitive-grant program from the central management unit.

The following outline describes one possible unfolding of this activity.

1. Special Program for African Agricultural Research provides a list of priority industries on the basis of the existing opportunity for scientific endeavor and acceptable investments to transform the industry and have significant impact on economic growth. SAATS selects industries form this list

2. SAATS considers proposals to fund industry studies in priority areas. Proposal include specification of implementing agents. Selected proposals are accepted, and funds allocated to the implementing agents.

3. Implementing agents gather detailed information from world-wide sources on technologies and investments which can transform the industry.

4. Implementing agents undertake study tours in conjunction with appropriate national and regional users' groups to visit sites where promising technologies are transforming industries.

5. The implementors and users' groups determine which of the technologies offers the most promising application to local African conditions.

6. A list of priority investments is prepared.

7. SAATS would consider proposals from agricultural technology development and transfer organizations for specific priority technology development, and may provide short-term technical assistance to work with the regional organizations, national agricultural research systems, donors and the private sector to find sources of investment capital for priority investments.

Special Program for African Agricultural Research's initial selection of industries to be analyzed could be based on knowledge of their importance in the region or continent. There would be an opportunity to extend or change this selection in the future as more information became available. Special Program for African Agricultural Research could hold a workshop of appropriate scientists to provide recommendations on the most promising industries to the Committee of Directors immediately after SAATS startup in September–October 1995. Collection of more detailed information about these industries could progress during late 1995 and study tours could be undertaken in early 1996.

Table 10. Summary of SAATS Cross Regional Activities

Activity	Date Initiated	Duration or Date Completed
Special Program for African Agricultural Research		
Industry Analyses		
Communications		

4.5. Actions by program outcomes

Program outcome 1: Increased use of profitable and sustainable technology

Program outcome 2: Increased availability of and access to profitable and sustainable technology

Short term:

1. Identify "low apples"
2. Screen and adapt "low apples"
3. Multiply and manufacture the technologies
4. Disseminate/distribute/demonstrate technoloties

5. Link groups (technology offices) for more efficient adaptation, validation and dissemination

6. Develop protocols among countries for the exchange and certification of technologies (seeds and planting materials)

7. Improve linkage between technology developers and technology users

8. Identify and support ongoing previous investment initiatives that have high payoff potential

9. Analysis of opportunities and constraints to capitalize on previous investments

10. Support the development and diffusion of appropriate technologies to respond to short-term opportunities

Long term:

1. Identify new markets in which African products are competitive

2. Solving second generation problems

3. Sustainable collaborative regional programs on selected priority areas

4. Apply a sub-sector approach to identify and support priority areas for long-term strategic research

5. Establish a process for the commercialization of technology

6. Provide support to nongovernmental organizations and other private sector organizations to demonstrate and promote improved access to technology

7. Establish and maintain an integrated and linking approach (research, transfer, use) to support agricultural transformation

8. Identify and support priority areas for long-term strategic research:

   - broad based analysis of constraints and opportunities
   - support development of profitable and sustainable technologies

9. Support collaborative activities within sub-regions that increase the availability and access to technologies to support national development objectives.

Program outcome 3: More effective and efficient use of human and institutional capacity to support national development objectives

Short term:

1. Develop capacity to identify "low apples" through technical assessment of problems and constraints for production and consumption:

   - industry analysis
   - adaptive research on best bets

2. Support coalitions of nationally based private and public agents and a decision making process:

   - institutional framework (private associations, foundations, etc)
   - develop appropriate governance mechanisms
   - develop process and procedures
   - identify constraints and opportunities and priority areas for the transformation of agriculture
   - information exchange

3. Establish a strategic planning process which includes priority setting capacity as well as monitoring and evaluation and develop coalitions to support this process:

   - in regional institutions (Association for Strengthening Agricultural Research in East and Central Africa in East Africa) criteria for proposals
   - within national agricultural research systems training workshops or contract services

4. Support specific short-term skill development to produce capacity for accomplishing specific tasks

5. Develop a communication capacity among research, transfer, and natural resource communities (national and regional)

6. Develop the capacity to obtain funds in the short term

7. Develop the capacity to document, publish and disseminate information.

Long-term:

1. Apply mechanisms to establish sustainable funding for national and regional enterprises.

2. Develop the capacity to link various parts of the sub-sector to support vertical coordination.

3. Develop the capacity to develop, screen, and adapt off-farm technology to support the transformation of agriculture.

4. Develop the capacity to support agricultural transformation through:

   - market analysis
   - policy analysis
   - policy formulation
   - transportation analysis
   - information exchange

5. Develop the capacity to ensure accountability for development impact.

6. Develop the capacity to coordinate multi-country collaborative programs.

7. Develop the capacity for effective participative governance of regional collaborative activities which enfranchises the private sector.

8. Develop the capacity to sustain funding in the long term.

9. Institutionalize the philosophy/culture/breadth of vision and develop a mission statement that incorporates the private sector/entrepreneurial spirit in addressing agricultural transformation and growth.

Program outcome 4: Advantageous policy and market environments for agricultural transformation in selected sub-sectors

1. Strengthening intellectual property rights (ability to apply for and receive patent protection).

2. Develop protocols to harmonize input markets (trade across borders, patents, certification/quarantine regulations).

3. Encourage policy analysis to identify constraints to free markets and market failures.

4. Use constraints analysis and analysis of rates of return to research to guide decisions on research investments and the allocation of resources between different research opportunities.

5. Develop a research and analysis network for agricultural and natural resource management policy:

   - establish an information system which can provide data needed for analysis

- analyze trade and constraints to trade across borders, particularly with regard to the flow and use if agricultural inputs
- analyze the cost and effects of different strategies, e.g., subsidies on inputs compared to improvements in road and market infrastructure
- analyze the need for and role of credit

6. Develop policy guidelines and incentives to promote improved natural resource management and environmental protection.

7. Establish coalitions which can represent users' interests and promote the development of priority commodity sub-sectors (e.g., trade associations, cooperatives, women's groups).

8. Promote increased participation of women in production and marketing activities.

9. Identify constraints and strengthen key elements of transportation, storage and market infrastructure.

10. Develop trade policy and information.

11. Establish an NPA agenda for agricultural technology development and transfer (financial management, intellectual property rights, certification/quarantine regulations, etc.).

12. Monitor the contribution of the agricultural sector to economic growth and the impact of the SAATS Initiative.

5. Program management

5.1. West African stakeholder survey

5.1.1. Background

5.1.1.1. Purpose

This survey attempts to identify potential beneficiaries, interest groups, and participants in a regional agricultural development and transfer program. Discussions focused particularly on the institutional aspects of regional collaboration. The views of stakeholders were solicited on priority needs with regard to national and regional action and issues, constraints, and opportunities with regard to improving regional cooperation.

5.1.1.2. Methodology

The West African Stakeholder Survey was implemented by two members of the SAATS design team accompanied by one of the USDA RSSA personnel from the agricultural technology development and transfer component of the PARTS project from September 13 to October 2, 1994. This team traveled to Niger, Mali, Cotê d'Ivoire, and Senegal. The team met with national agricultural research systems leaders, USAID mission and Regional Development Support Organization personnel, international agricultural research center staff, personnel from USAID projects working in agricultural technology development and transfer, and some nongovernmental organizations. INSAH brought together a number of national agricultural research systems scientists to meet with the team. An informal interview guideline had been prepared in advance and was used as the basis of the different interviews. The exact questions varied depending on the audience and the time available. In each case a questionnaire, which formed part of the interview guideline, was left with a fax or email number in case interviewees wanted to make additional comments.

5.1.2. Findings

5.1.2.1. Organizations

No single organization specifically groups the twenty-three countries of West and Central Africa, either in general or in regard to agricultural research and technology transfer. CILSS and INSAH serve these respective functions for the nine countries in the Sahelian subregion. There is no similar political institution for the coastal (humid) subregion and no organization is responsible for the coordination of agricultural technology development and transfer in the coastal subregion. ECOWAS has an agricultural committee, but neither the committee or ECOWAS in general is considered very effective. CORAF regroups the francophone agricultural research directors and sponsors certain networking activities. But CORAF has only recently begun to integrate the anglophone countries, has

not yet dealt with the integration of Nigeria, and is considered to be too strongly influenced by French representatives to provide an appropriate basis for local governance.

To date, the international agricultural research centers serving in the region have served as an institutional base for organizing regional agricultural research. The principle of empowering Africans to govern their own institutions requires that SAATS search for a new institutional base.

The government institutions visited by the team consisted primarily of the national agricultural research institutes. Attempts to interview other members of the ministries of agriculture were generally not successful. In several cases, personnel in projects related to agricultural technology development and transfer were also interviewed.

Interviews were conducted with personnel from several national and international nongovernmental organizations particularly regarding their involvement in technology transfer. Interviews were also held at CIRES, which is the premier social science research institute in the region.

5.1.2.2. Overview of stakeholder perceptions of regional issues, constraints, and opportunities for improved regional cooperation

Perhaps the strongest and most consistent message from West Africa was the need to empower African institutions to make decisions, set priorities, and allocate funds that are to be used to benefit West Africans. There is strong agreement that regional activities should be based on national development objectives and priorities based on identifying common problems, constraints, and opportunities across a number of countries.

The regionalization of research was supported by agricultural research directors, who have been involved in Special Program for African Agricultural Research, INSAH, CORAF, and other regional activities. They perceive regional programs as supporting national agricultural research systems if Africans are empowered to govern the decision-making institutions. In many cases there is a large gap between the knowledge of the directors and their researchers with regard to regional programs. Frequently national agricultural research system researchers contacted had little knowledge of regional research activities and their organization. In several cases the directors took advantage of our meetings to inform researchers about the Special Program for African Agricultural Research initiative and plans to establish regional institutions under the frameworks for action (INSAH meeting, IDESSA meeting). National agricultural research system researchers often suggested that those systems are the priority research institutions and that funding should be channeled directly to them. They found a regional research approach acceptable as long as regional efforts support and strengthen national systems (rather than replace them) and are based on strategies defined at the national level. With the exception of Mali, national agricultural research system representatives indicated that they often had difficulty obtaining financing for research projects and that their institutions faced severe financial constraints.

National agricultural research system representatives agreed that regional strategic planning should be based on common national objectives and that the systems' representatives should be empowered to govern the regional organizations. Most researchers appreciate the efforts of the international agricultural research centers working in the region. They felt, however, that international agricultural research centers should provide services to national programs rather than direct national efforts through their control of network funding. Researchers felt that national representatives rather than international agricultural research centers should be responsible for the governance of regional institutions and the allocation of financial resources to activities.

National agricultural research system representatives were very positive about the contribution that improved agricultural research and technology transfer could make to economic development. They supported the demand-oriented approach of the SAATS Initiative. However, demand was rather narrowly defined as responding to the needs of farmers. Interviewees regularly cited the farming systems related concepts of needing to make technology more relevant by responding to the needs of farmers and to improve the transfer of results to farmers. Some mentioned the need to work more closely with nongovernmental organizations and other private-sector groups to broaden and improve the transfer mechanisms. Responding to the needs of actors in the postharvest area and market demands was less a part of their vocabulary. National agricultural research system representatives also cited the need to improve input delivery sysems and commercialization of products to enhace the production environment. There was little indication that researchers had thought about trying to predict what the market opportunities might be in five to fifteen years.

The reaction of researchers to the "dirt to shirt," production to consumption definition of a commodity subsector was less clear. Researchers recognize the usefulness of a systems approach and the need for inputs and market systems to support commodity production. However, researchers are not accustomed to thinking that they need to do research on nonproduction aspects of the system. There is little in their institutional culture that advocates the need to work with, or have much in common with, the private sector and other agents involved with aspects of the commodicty subsector such as agricultural inputs, postharvest marketing, and processing, and related issues involving postharvest production. In most cases, their training and institutional culture focuses their attention on production.

5.2.3 Stakeholders priorities for possible regional action

Stakeholders did not present clear priorities with regard to commodities or thematic areas that should be the focus or regional actions. The priority commodity or thematic areas suggested by researchers (and other interviewees) tended to reflect their discipline and area of research as well as their country's climate conditions. There was agreement that maize, rice, and livestock are important throughout West Africa. Sorghum, millet, and cowpea were cited as important in dryer areas while roots, tubers, and tree crops are

important in humid coastal areas. Natural resource management in general, and soil and water conservation in particular, were often cited as areas that needed more attention.

Researchers tended to promote an ecoregional approach to regionalization. However, most agreed that in West Africa the marketing opportunities are between ecoregions. This trade between regions is perhaps most obvious for livestock, but it is also viable for fruits, root crops, vegetables, and processed goods.

For national agricultural research system researchers, the primary role of regional activity is to provide networking in the form of peer interaction and information exchange. Peer may be defined either within a discipline (agronomy, entomology) covering a group of related crops or pertaining to a specific commodity. There was little mention of needing to expand the interaction to all actors in a commodity subsector or to increase exchanges between social scientists and physical scientists. While they recognize the need for improved input delivery, processing, marketing, and policy, it was not clear that they recognized any need for a commodity research network to expand to include these other aspects. For the most part, national agricultural research system researchers familiar with the maize, rice, and sorghum networks funded under PARTS were satisfied with the manner in which they function, with one exception. That exception is that regional activities should be governed by representatives of the countries in the region and not controlled by the international agricultural research centers.

National agricultural research system directors had a broader view and supported collaborative networks which make use of joint planning and rationalize and share tasks among country programs. National agricultural research system directors mentioned the need for research on policy issues, on postharvest constraints such as processing, transportation, and marketing, and on improved sustainability and natural resource management. All national agricultural research system representatives were supportive of efforts to improve the stability of funding to national and regional institutions. Sahelians suggested that INSAH provided a forum which could serve as a regional coordinating organization. Coastal representatives were not convinced that INSAH was an appropriate forum to represent their interests but had no alternative to offer.

5.2. SAATS issues

5.2.1. Institutional

The frameworks for action from the Special Program for African Agricultural Research (SPAAR) provide a basis for developing a system of regional governance and management. Two frameworks for action have been prepared for WCA, one for the Sahel subregion and another for the coastal humid and subhumid subregion. This seems to imply setting up two separate umbrella organizations for collaborative agricultural research in West and Central Africa. The Sahel group has an established institutional base in the Institut du Sahel, Bamako. The coastal group does not have an obvious base of

institutional support. It is not clear how quickly the coastal countries can organize to develop an institutional base for regional agricultural research activities.

The frameworks for action (particularly the more complete framework for action from East Africa) proposes using the executive secretariat and the seventeen national agricultural research institutes as the foci for financial management and accounting. This poses some difficulty in that not all of the national agricultural research institutes in the region are certified to handle USAID funds. One possible solution considered was to use the existing (commodity) networks to be responsible for financial management and accounting. But it is often the international agricultural research center that is certified and responsible for the network funds. The future of the commodity networks is uncertain as networks are merged and rationalized. Local governance implies that the institutional base for such networks will change as the frameworks for action become functional. As the chairpersons of networks rotate among national agricultural research system representatives, the appropriate locus for financial management might also need to change. A strong network chairperson aided by the framework for action executive secretary may not need a coordinator per se.

National agricultural research institutes have the advantage that they are developed and relatively stable institutions (compared to networks). While not all national agricultural research institutes in the region are certified, they all need to develop the capacity to manage finances and accounting if the consolidated funding mechanisms are going to work. The frameworks for action argue that regional research efforts will only be effective if national agricultural research systems have the strength and capacity to implement them. While USAID is not likely to support all of the networks authorized by the directors' committees, there well may be more priority networks than there are national agricultural research systems. There are presently an estimated one hundred networks in the region and only twenty-seven national agricultural research systems.

Initially the executive secretariats will need to be responsible for financial management and accounting (the Sahel Institute might either serve as the executive secretariat for the Sahel group of countries or provide an institutional base for an elected or appointed executive secretariat). Over time, some of this responsibility may be devolved to national agricultural research institutes serving as lead institutions or the institutional bases of the chairpersons for specific networks and themes and for local research activities funded by regional initiatives.

5.2.2. SAATS matrix

The West and Central Africa concept paper team initially hypothesized that the appropriate SAATS matrix consisted of vertically integrated commodity networks in the columns and cross-cutting themes as the rows. Since most of the networks need to be expanded to include a role for user groups, broader definitions of constraints, natural resource management considerations, policy analysis communications, and so forth, a network-by-theme matrix seemed appropriate. However, as identified in the East African

framework for action, it is really the national agricultural research systems (countries) that are the base institutions and that need these capacities to improve national-level research and technology transfer. They are also the units represented on the directors' committee and the unit for which impact must be demonstrated. While a three-dimensional matrix might be postulated, this is probably overly complex and perhaps even misleading. National agricultural research systems and their representatives on the directors' committee will perceive commodity programs and theme related programs as being in competition for priority and funding.

If national agricultural research systems are to be the columns in the matrix, all of the commodity networks and themes must be rows in the matrix conceptualization. It is not clear whether the framework for action organization will allow representatives of the commodity networks to serve on the technical committees, working groups, or task forces[1] for natural resource management, policy analysis, communications monitoring and evaluation, etc. It also becomes more clear that the theme related working groups and task forces will compete with the existing commodity networks for priority and funding. It is less clear how to integrate these themes effectively into the commodity networks if they both occupy the same axis in the matrix. Since the national agricultural research systems are an important user group for the networks, the integration of themes into networks will likely be indirect, that is, demanded by the national agricultural research systems network users as they develop demand-driven subsector approaches to agricultural technology development and transfer.

Many of the themes suggested appear to be more important than many of the existing narrowly focused commodity networks but are presently missing in the matrix. These themes would also provide many of the elements that seem to be needed to broaden the commodity networks definition of the system to include all of the commodity subsector from input supply to consumption. However, most of these themes do not have an existing network. Supporting networks for these themes implies creating additional new networks when there are already too many.

It was often said that the farming systems approach could only become successful when it had been fully integrated into research and extension activities and had disappeared as a separate entity. The same seems to be true of many of the important themes proposed in the matrix. As long as they remain separate activities rather than integrated functions of national agricultural research systems activities and agricultural technology development and transfer, they will not achieve the desired goals.

1. For the purposes of this paper, technical committees, working groups, and task forces will be treated as interchangeable.

One alternative is for USAID to support technical committees, work groups, or task forces for priority themes composed of both network and national agricultural research systems representatives. This is possible without greatly expanding the membership in that each network delegate is also a national agricultural research system representative. (While requiring more care, many national agricultural research system representatives would also be network delegates.) In this manner, work could move forward to integrate the themes into both the networks and national agricultural research systems at the same time.

A second alternative would be to support a very limited number of networks on "federating" themes perhaps along the lines of the Highlands Initiative for East Africa. These networks would be set up to address a set of issues that would require a broad, multidisciplinary, and multicommodity approach. Many of the priority themes (postharvest activities, natural resource management, policy analysis, constraints analysis, communications, finance, agricultural technology development and transfer, monitoring and evaluation, and training) would fit within the broad ecoregional focus of such networks.

Perhaps in the Sahel region activity could be focused on an initiative to reduce land degradation and the effects of drought, which explicitly includes food security and income generation considerations. It is less obvious what broad "federating" theme might be appropriate for the coastal humid and subhumid zone.

5.2.3. Communications

To operate effectively, exchange ideas, and reduce travel costs, all of the regional and national agricultural technology development and transfer activities need better communication. One option for beginning to improve this communication would be to provide at least one satellite down-link to each national agricultural research system. This would allow fax and email communication between the executive secretariat and the national agricultural research system, allow the directors to communicate, and provide an opportunity for network and task force representative to exchange information. With a central down-link established, other national and regional projects would install their own down-links to take advantage of the system established. In this manner, a basic investment in communications technology could be leveraged to upgrade communications capacity significantly, which would serve both regional and national objectives. This would seem to be one of the most important steps to increasing the effectiveness and efficiency of both the national agricultural research systems and the regional agricultural technology development and transfer initiatives.

5.2.4. Priority commodity and thematic areas for West Africa

The stakeholder analysis was only moderately successful in identifying priority commodity, thematic or areas of technology for West and Central Africa. In part this is due to the wide range of climate and environment conditions which are represented

across the twenty-three counties. Livestock, sorghum, millet and cowpea and to a lesser extent groundnut are important in Sahelian areas. Most Sahelian countries also include Savanna areas where livestock, cotton, maize and sorghum are the dominant enterprises. Specialty crops such as rice, fruit and vegetables are regionally important in both areas.

Rice, cassava, other tubers (yams, cocoyam), maize, bananas, plantain tend to be the staple food crops in the coastal (humid zone) countries. These countries also produce coffee, cacao, and palm oil as traditional export crops, and tropical fruits. Most coastal countries also have savanna areas, where, as in the Sahelian country savanna zones livestock, cotton, maize, and sorghum are important.

Several of the Sahelian countries run consistent deficits in food production while others vary from surplus to deficit depending on the year's rainfall. In most of the Sahelian countries consumption of rice, food oils, root crops, and tropical fruit exceeds production. Sahelian countries have surplus production of livestock and cotton, and potentially maize and sorghum in years of good rainfall. Rainfall is highly correlated across the region, and Sahelian countries often have surpluses and deficits at the same time, reducing their ability to trade with their Sahelian neighbors.

Food production in coastal countries also varies with the weather, but it is less risky than in the Sahel and not necessarily correlated with years of high Sahelian rainfall and production. Coastal countries often have marketable quantities of their staple food crops such as cassava, yams, bananas, plantain, maize and to a lesser extent rice. Rice is far and away the preferred midday meal in most West African urban areas. Demand for rice is so much greater than production that most countries can consume whatever amount of rice is produced, if it is competitive in price and quality with imports.

Trade between coastal and Sahelian countries has much greater potential to help stabilizing production and consumption across the region than does trade within either region. Livestock is perhaps the most important commodity traded between the Sahel and coastal zones, but certainly not the only one. Consumption studies in Bamako (Holtzman et al. 1991) indicate that the demand for these products is large and growing with a strong tendency to replace coarse grains in the evening meals of urban populations. The CFA devaluation provides an important opportunity to increase coastal-Sahelian trade. Livestock products are among the few for which there is a high elasticity of demand. Palm oil from the coast may be able to displace imported soybean based food oils in Sahelian countries. Overcoming constraints which would allow expanded trade between subregions appears to be the first priority to transforming agriculture across the region.

Priorities among commodities are more difficult to identify. Livestock is certainly important in Sahelian production systems and the consumption of all peoples of the region. It is also an area that seems to have been neglected in recent years.

Rice is certainly a priority in terms of consumption, but there are still questions about whether it can be produced economically in West Africa. Rainfed lowland (*bas*

fond) production is the component of rice production that seems to have the best chance of producing rice at a price competitive with imports. WARDA has identified this as their priority zone of intervention.

Southern Mali quadrupled maize production in a four year period from about 1978 to 1982, causing the price to crash and maize production to decline. Again in the early 1990s maize production increased spectacularly, overloading the Mali Textile Development Company's marketing system and causing them to rescind their price guarantee. There seems to be little question that the Savanna zones can produce large surpluses of maize, if there was a means to market the surplus. The search for new maize uses and products via processing and transformation seems to be an area of great potential for stabilizing prices and cereal crop production for the region.

While maize producers in Southern Mali produce maize for sale, they produce sorghum and millet to ensure that they will have a minimum harvest and something to eat in years of poor rainfall. In the Sahel zones they are the staple food crops along with cowpeas. While they have less production potential than maize, they feed a large percentage of the population in the dryer zones. Areas of less than 600 mm of rainfall may not be able to consistently produce enough food for the population in those zones. Most farmers have strategies which combine the production of sorghum, millet, and cowpeas with livestock production and off-farm employment. Until trade and regional production is much more certain than it is to date, it would be risky to reduce the efforts to maintain sorghum and millet production in the face of a declining natural resource base.

The CFA devaluation also provides an opportunity to take another look at traditional tree crop exports such as coffee, cacao, rubber and oil palm. Rumors indicate that coffee production is again expanding rapidly based on the combination of higher world prices and higher prices to farmers following the devaluation. Palm oil would seem to be in an advantageous position to replace high priced soybean based food oil imports in Sahelian countries.

5.3. Agriculture and natural resources in WCA: recent trends and lessons learned

There are a number of broad trends in donor support and development orientation that set the environment in which agricultural technology development and transfer activities must operate. Some of the more important include the effects of structural adjustment, market liberalization, decentralization and democratization. The role of government in developing countries is changing and this affects the structure and function of development activities.

An important lesson on a world wide scale in recent years was that centrally planned economies suffer many deficiencies that hinder economic growth. Prices set by bureaucracies often fail to provide incentives for effective and efficient production and resource use. Many governments have liberalized the agricultural input and product

markets, increasing the relevance of market signals as indicators of demand and opportunity and the importance of the private sector in commercial activity.

The failure of centrally planned economies and the need for fiscal austerity is pushing governments to redefine their role as setting policy environment and providing regulation, while turning over an ever increasing number of implementation functions to the private sector. In part this is necessary because government agencies do not have the resources required to implement a wide range of activities once deemed to be the domain of government. The new role of government requires a much greater focus on policy and establishing incentives so that individuals, private enterprise, and markets behave in a manner that contributes to the attainment of policy objectives. Decision makers need access to information based on policy analysis. The importance of policy and the behavior of individuals, organizations and institutions (including markets) will involve a much larger role for economic and social science research than has been accorded in the past.

Like other groups in the system, researchers also need incentives to provide relevant research in an effective and efficient manner. The incorporation of users groups in setting priorities can help improve research relevancy. The frameworks for action also talk about the success of competitive research grants and contracts, but do not appear to establish this as part of the framework for action process. The frameworks for action should be encourage to incorporate the use of competitive proposals into the process of allocating research funds.

Many of the problems with regard to natural resource management and environmental protection require the capacity to do cross-sector analysis, develop policy and facilitate negotiations between actors in several sectors of the economy. Land and water resources are in the greatest jeopardy when several sectors or sub-sectors of the economy want to use the same resource. Rivers and their valleys are often among the endangered resources. The river valley resources are used by agriculture for irrigated and nonirrigated production activities, to dispose of pollutants, and to graze and water livestock; by industry for hydro-electric production and to dispose of industrial pollutants and waste; by urban populations for drinking water and to dispose of sewage and waste; and wetland areas are important to ground water regeneration and as an environment for wildlife. Determining priorities and developing rules to regulate use across sectors is by definition outside the scope of any one sector.

Another important lesson learned is that only those objectives and programs supported by local populations or other stakeholders have much chance of succeeding in the long run. Positive incentives and participation in decision-making are more successful in providing such support than are negative incentives and policing and are therefore keys to long-term sustainability. The related trend has been toward increasing decentralization and democratization, the devolution of authority from central governments (and donors) to local institutions and the empowerment of local populations to have a greater role in decisions affecting their lives. This trend supports local governance of donor funded

activities including the use of a representative body to set priorities and allocate funds with regard to regional agricultural technology development and transfer activities. This is one of the strong arguments for accepting the general Special Program for African Agricultural Research structure and allowing it to develop as an institutional setting for regional agricultural technology development and transfer programming. National agricultural research systems also need to provide a greater role for technology partners and users in determining research priorities and allocating research funds. For example, funding might be withheld from networks or task forces which have not integrated users groups into their decision-making process on priorities and the allocation of funds.

Getting prices and policies right may be necessary but is not sufficient to achieve objectives which require a long-term process. Sustaining that process requires institutional support, which in most cases implies the need for institutional development. In the past, regional agricultural research has been supported by the international agricultural research centers. Different institutions will have to take their place in supporting regional agricultural research as national representatives become responsible for determining priorities and allocating funds. Regional institutions which allow representation of national institutions and participation of users must be found or developed to support the long-term process of agricultural technology development and transfer. international agricultural research centers will also have to evolve to better serve the needs of the regional and national users of their products and services.

The importance of the private sector in sub-sector systems is not adequately addressed in the framework for action proposals. Private sector actors in input supply, technology diffusion, production, processing, storage and transportation, marketing, etc. need to be explicitly integrated into the agricultural technology development and transfer decision-making process. At the national level, private sector representatives should be incorporated into Agricultural Research Councils and user groups related to agricultural technology development and transfer activities. At the regional level, a structure and procedures should be established which allow private sector representatives to become members of networks and task forces.

While agricultural production remains important, it will not serve the purposes of food security and economic growth if the products can not be marketed. Marketing and postharvest activities have been neglected in many of the agricultural sub-sectors. The search for new products through processing and transformation has seldom been integrated into marketing activities. For example, surplus maize production in southern Mali has caused maize prices to crash twice in the last fifteen years. The maize sub-sector in Mali can produce much more maize than it can market. At this point, research on marketing and new maize products should receive a higher priority than maize production.

Another lesson learned is the need to sustain the natural resource base. The concerns of natural resource management have not always been well integrated into agricultural programs. While production and income generation are key goals of agricultural

programs they can not be maintained if the natural resource base which supports them is destroyed. Much of the increase in African agricultural production over the last twenty years has been based on increases in the land area under production. In the future increased intensification of agricultural production will be necessary to maintain growth in agricultural output. This intensification of agricultural systems is dependent on agricultural technology development and transfer.

Technologies do not result in economic growth unless they are effectively communicated to users and adopted. Research does not serve the purpose of economic growth unless it responds to constraints experienced by producers and other actors in the sub-sector system (processors, marketers, input suppliers, consumers, etc.). To date there has been a huge gap between research and adoption. A demand-driven, client oriented, sub-sector approach to constraint analysis will help improve the relevancy of technology generation, leading to improved adoption rates and economic growth.

5.4. WCA SAATS Initiative and agriculture and natural resources' relationship to existing strategies and programs and USAID's comparative advantage

Special Program for African Agricultural Research. The SAATS Initiative parallels and may provide parallel funding to the multidonor Special Program for African Agricultural Research program and the ecoregionally based frameworks for action, which it has produced. The Special Program for African Agricultural Research appears to be intent on establishing an institutional framework to support regional agricultural research governed by representatives from national agricultural research systems. It is not yet clear whether this institutional framework will provide adequate support for the transfer aspects of agricultural technology development and transfer. An institutional framework, while expensive, is necessary to realize long-term objectives and support with regard to agricultural technology development and transfer. USAID can influence the institutional framework and leverage its funding by providing support for specific aspects of the Special Program for African Agricultural Research umbrella. National agricultural research systems and existing networks are weak with regard to the range of constraints analyzed, particularly in the areas of postharvest technology, marketing and commercialization, and diffusion methods. Other areas which need strengthening include the integration of agriculture and natural resource management, cross-sector and policy analysis, the incorporation of user groups in decision-making, financial management and transparent accounting, and monitoring and evaluation. While training has been a strength of past networking activities and donor support to national agricultural research systems, expansion into these new areas and the inability to keep staff given existing incentives dictate that continued training will be necessary. USAID should focus on supporting these underdeveloped areas of network capacity and national agricultural research system capacity, with particular emphasis on expanding their roles beyond production to improve subsector performance.

The Special Program for African Agricultural Research has a multidonor secretariat located in the World Bank, Washington. Frameworks for action have been prepared separately for Southern Africa, East Africa, the Sahel, and the humid and subhumid zones of West and Central Africa. Integration and consolidation of the two frameworks for action from West and Central Africa is under consideration. The frameworks for action call for the following structure:[2]

1. A political body composed of the Regional Conference of Agricultural Ministers.
2. A directors' committee composed of the national directors of agricultural research, which will establish broad priorities and funding allocations.
3. A small executive secretariat to assist the directors' committee in its functions.
4. Technical committees composed of national directors responsible for supervising specific collaborative regional programs authorized by the framework for action and directors' committee.
5. Task forces or working groups of national agricultural research system scientists (also international agricultural research center scientists and user group representatives) responsible for program implementation including setting technical priorities and selecting specific research proposals for funding.

PARTS. The USAID financed PARTS project has made significant contributions in the analysis of policy, constraints and natural resource management and provides guidance on information systems and monitoring and evaluation. Analytical capacity needs to be developed in the regional networks and the national agricultural research systems. U.S. universities are strong in both analysis and institution building. Critical analyses needed immediately might be implemented through the PARTS project. Work toward developing analytical capacity in the region might be supported jointly by PARTS and SAATS activities. The analysis capacity demonstrated by U.S. universities should be available to guide and support the development of analytical capabilities in the regions.

PADRES. One spin-off of the PARTS project, the PADRES project with INSAH is a sort of mini-SAATS. It supports a continuation of the Food Security Program, will help coordinate agricultural research in the Sahel region, and will provide support in information services. It is not clear if PADRES will in effect fund the initiation of the Sahel region framework for action and its executive secretariat. If the PADRES-funded agricultural research coordinator can serve as, or support, the framework for action executive secretariat, it would be an important contribution to the larger SAATS and Special Program for African Agricultural Research initiatives.

2. Each FFA uses slightly different terminology and or definitions of the roles of the structural elements, particularly concerning technical committees, working groups, and task forces.

INSAH. The Sahel Institute has a mandate from CILSS to coordinate research throughout the Sahel. It coordinated the elaboration of the framework for action for the Sahel countries; with funding from the PADRES project, it is in the process of hiring a research coordinator. INSAH provides an institutional base with certified financial management capacity for regional activities in the Sahel.

CRSPS. The CRSPs have also made important contributions to agricultural technology development and transfer, particularly to agricultural research, training, and support to commodity networks. While most are commodity focused, TROPSOILS works on the resolution of general problems (soil fertility, soil and water conservation and rehabilitation) that are often cited as more immediate constraints than commodity production. TROPSOILS also has the potential to help integrate agricultural programs and natural resource management with a focus on sustainability.[3] The CRSPs demonstrate the capacity of US Universities to work with national agricultural research systems and networks to catalyze agricultural research and provide training.

Strengthening African Agricultural Research and Faculties of Agriculture project. The Strengthening African Agricultural Research and Faculties of Agriculture project was a research project that provided funding to fifteen separate research programs, including the Michigan State Food Security Program, Wisconsin's Land Tenure Center, WARDA, and Southern African/University of Florida Heartworm Program. An evaluation report indicates that fourteen of the fifteen programs were successful in producing significant research results. The Strengthening African Agricultural Research and Faculties of Agriculture project is one more indication of US capacity and competitive advantage in research oriented activities.

SAFGRAD. The SAFGRAD project supported and helped coordinate agricultural research on major staple food crops and related farming systems including sorghum, maize, millet cowpea and groundnut. Support to establish commodity networks related to these crops was originally channeled through the SAFGRAD project. Continuing support to these networks is from the PARTS project and channeled through the respective international agricultural research centers concerned with the commodities. The commodity networks, in collaboration with the international agricultural research centers and CRISPs have achieved notable success in the release of new varieties and in training local scientists.

IARCs. international agricultural research centers operating in the region continue to be an important source of strategic research. They have contributed greatly to commodity research and helped coordinate regional commodity networks. National agricultural research systems complain that international agricultural research centers have controlled commodity research and regional initiatives rather than serving the national

3. The Niger USAID Mission was particularly dismayed when TROPSOILS activities were terminated in Niger; it spoke glowingly of that program's contribution.

agricultural research system. Governance of regional efforts will devolve to national agricultural research system representatives under the Special Program for African Agricultural Research program. This will require a new role for the international agricultural research centers and determining the relationship between them and the Special Program for African Agricultural Research structure. international agricultural research centers have often been accused of doing strategic research that is too basic to serve the (immediate) needs of national agricultural research systems. As the research capacity of regional initiatives and national agricultural research systems expands, international agricultural research centers can be expected to withdraw from applied and adaptive research to focus even more on strategic research.

CORAF. CORAF is a conference of (Francophone) African Agronomic Research Directors, which also serves as an umbrella for agronomic research and networks in the Francophone countries. It has basically the same composition and functions as the Directors' Committee proposed under Special Program for African Agricultural Research, except that it does not include the English speaking countries and the domain is somewhat limited to traditional agronomic research. Hopefully, Special Program for African Agricultural Research will provide an institutional basis which includes Nigeria, Ghana and other Anglophone countries.

SPARK. SPARK is one of several bilateral USAID funded agricultural research projects in Africa (Mali). Its focus is to improve the effectiveness and efficiency of Mali's Institut d'Economie Rurale (IER). It has a strong focus on financial management and transparent accounting, and will attempt to help develop a Consolidated Financial Mechanism for the IER. It is one of several projects which may be able to identify acceptable models of financial management and transparent accounting for use in the national agricultural research system and regional institutions.

Animal Productivity and Export. The Animal Productivity and Export (APEX) project in Mali is interesting in two respects. It is strongly oriented toward lifting constraints in marketing and commercialization to improve subsector productivity. It also has developed a system of user groups which interact with agricultural research centers in the different regions of Mali. Animal Productivity and Export project contracts with the national agricultural research institute for research, but the local user group must review and accept the work before the final payment on the contract is made.

Community Based Natural Resources Management. The Community Based Natural Resource Management (CBNRM) project in Senegal is designed to channel funds to local institutions in rural Senegal. These local institutions then contract with public or private agricultural extension and research organizations to provide the services desired. Here the users groups not only have a role in setting the priorities and allocating funds of agricultural technology development and transfer organizations, but actually hire those services as they deem necessary to meet their demands.

5.5 Plan of action

The SAATS Initiative needs a time phased strategy for planning what activities can realistically be established in a particular time frame. Conceptually, the initial five-year SAATS program can be divided into a startup phase and a second phase characterized by development of the regional coordinating institutions and more effective harmonization and coordination of regional technology systems. Eventually, a third phase beyond the scope of the five-year funding is likely to be necessary to achieve the establishment of effective and efficient programs and institutional maturation.

The startup phase will proceed differently in East and West Africa, because West and Central African countries have not yet identified an institutional base in West Africa to serve as a regional coordinating organization. Association for Strengthening Agricultural Research in East and Central Africa is not yet legally incorporated as a regional coordinating organization in East Africa, but expectations are that it could be operational by spring 1995. During startup, the SAATS Initiative will work with Association for Strengthening Agricultural Research in East and Central Africa to help it develop as a functional regional coordinating organization with governance by national representatives.

5.5.1 SAATS startup

SAATS will help establish and sustain regional (or subregional) organizations governed by national representatives to harmonize and coordinate national and regional technology systems. In these organizations national representatives will be empowered to make decisions, set priorities and allocate funds. The model for this coordinating body will be the framework for action institutions being developed with support from the multidonor Special Programs for African Agricultural Research Initiative. This model is based on principles agreed to by the national agricultural research systems directors. Plans for such institutions have been formalized in the form of Association for Strengthening Agricultural Research in East and Central Africa in Eastern Africa and SACCAR in Southern Africa. In West Africa, progress in the development of the framework for action organization(s) is less advanced. Proposals call for two subregional coordinating organizations, one for the arid zone (CILSS countries of the Sahel), and a second for the more humid coastal zone of West and Central Africa. Special Program for African Agricultural Research organizers hope to integrate these two into a single coordination institution for West and Central Africa sometime in the future.

SAATS will build on the accomplishments of past investments in the PARTS financed networks. The regional coordinating organizations are not yet ready to receive funds and take over coordination of these networks. To avoid their demise because of this logistical disjunction, SAATS should consider providing limited funding to these seven networks through the existing financial and management mechanisms. SAATS funding provided directly to these networks would decline each year during a three year transition period. Each year during this transition, the networks would have to look to the regional coordinating organization for an increasing share of their financial support. After three

years direct funding from SAATS would be phased out. Their continuation after the transition would depend on the priorities and allocation decisions made by the regional coordinating organization.

Since East Africa is more advanced in establishing a regional coordinating organization, SAATS should consider initially focusing on developing systems to support and interact with Association for Strengthening Agricultural Research in East and Central Africa. Initial support to Association for Strengthening Agricultural Research in East and Central Africa would continue to use the existing financial mechanism of channeling funds through the CGIAR Secretariat to international agricultural research centers, which support priorities set by Association for Strengthening Agricultural Research in East and Central Africa. SAATS would consider changing this system to channel financial support to the regional coordinating organizations through the Special Program for African Agricultural Research Secretariat. Special Program for African Agricultural Research would also seem to have a comparative advantage in helping the regional coordinating institutions establish transparent and performant financial management and accounting systems which conform to the requirements of donors, including USAID. SAATS would explore with Special Program for African Agricultural Research the possibility that Special Program for African Agricultural Research can help regional coordinating institutions implement financial management and accounting systems and otherwise promote their institutional development. SAATS could consider providing modest financial support to Special Program for African Agricultural Research to serve as a catalyst to study how the World Bank multidonor system can support institutional development and implement financial management and accounting systems.

Association for Strengthening Agricultural Research in East and Central Africa needs to establish a process to determine priority subsectors/industries and appropriate investments/technologies within those subsectors or industries. Industrial analysis is a process which provides an appropriate base for such decisions. One alternative for SAATS funding would be to provide funding and short-term technical assistance to Association for Strengthening Agricultural Research in East and Central Africa to support a process of industrial analysis for three to five selected priority industries. The process will need to consist of several steps:

1. The Association for Strengthening Agricultural Research in East and Central Africa selects priority industries on the basis of the existing opportunity for scientific endeavor and acceptable investments to transform the industry and have significant impact on economic growth.
2. Detailed information is gathered from world wide sources on technologies and investments which can transform the industry.
3. Study tours are undertaken by task forces in conjunction with appropriate networks to visit sites where promising technologies are transforming industries.
4. An appropriate task force determines which of the technologies has the most promising application to local conditions.

5. SAATS would consider Association for Strengthening Agricultural Research in East and Central Africa proposals to fund specific priority technology development and provide short-term technical assistance to work with the Association for Strengthening Agricultural Research in East and Central Africa, national agricultural research systems, donors, and the private sector to find sources of investment capital for specified priority investments.

Association for Strengthening Agricultural Research in East and Central Africa's initial selection of industries to be analyzed could be based on knowledge of their importance in the region. There would be an opportunity to extend or change this selection in the future as more information became available. Association for Strengthening Agricultural Research in East and Central Africa could hold a workshop of appropriate scientists to provide recommendations on the most promising industries to the Committee of Directors immediately after SAATS startup in September–October 1995. Collection of more detailed information about these industries could progress during late 1995 and study tours could be undertaken in early 1996.

The industrial analyses should be updated every two years to provide a continuing basis for the selection of priority technologies and investments. Association for Strengthening Agricultural Research in East and Central Africa could request to use SAATS funds to conduct additional industrial analyses or study tours. The information would be shared with the Southern and West African regional coordinating organizations. SAATS would support a similar process in West Africa, when the regional coordinating institution(s) are functional. The two sets of industrial analyses would build on and reinforce the other.

Another alternative activity which might be undertaken in the first year of SAATS is the development of sustainable funding mechanisms for the support of national agricultural research system and the regional coordinating institutions. SAATS would fund a contract for technical assistance to help each of the regional coordinating agencies study and implement the most promising. Several of these including debt-for-development conversion, check-offs and commercialization of patented products by nature are more readily applied at the national level. National level decision makers would probably have to decide to pass some portion of these funds to a regional entity, for them to be applicable to the regional coordinating organizations. Endowments or foundations appear to be the most appropriate nontraditional funding source for regional organizations. An endowment could accept funds from any of the previously mentioned sources as well as from different donor programs. It would provide a means of managing the capital to provide stable long-term resource flows to complement other available funding sources. This work should build on the accumulated experience of the Sustainable Funding Project.

One of the institutional issues not fully addressed by the framework for action approach to establishing regional organizations is how to include representation of the private sector and other users groups in the decision making process concerning technol-

ogy systems. The Board of Governors of an endowment would normally be chosen from a cross-section of society. Rules of selection could be established which ensure that the private sector and user groups do have representation on the Board of Governors. As the endowment becomes a significant factor in the funding of the regional coordinating organization, the incorporation of the private sector and other user groups into the decision making process of those institutions would be ensured.

Another alternative for first-year SAATS funding, particularly in West Africa, would be to support a communications program. SAATS could fund the computer and satellite telecommunications equipment necessary to allow the scientific community to communicate via Email and access to Internet. Improving telecommunications systems would increase the communication between the national agricultural research system directors and scientists participating in task forces and networks. This would make regional efforts both nationally across countries more effective and reduce transaction costs, also making them more efficient. Other local, national and regional projects and programs would join an existing system over time and leverage the initial investment. It also provides a means to significantly improve the flow of information to scientists. One model developed by WARDA searches publications and sends annotated bibliographies to WARDA and rice network scientists on the basis of key works selected by the scientists as being related to their areas of interest. It would be interesting for SAATS to explore an institutional base to provide this function to a wider cross-section of scientists, from scientific publications and from the Internet.

In several areas of endeavor related to technology systems, the national agricultural research systems and, therefore, the existing networks appear to have less capacity than desired. Regional coordinating organizations can make a major contribution by removing these deficiencies, but what they will establish as priorities cannot be determined in advance. Working to improve the capacity of the national agricultural research systems and networks in these areas provides a number of alternative activities for SAATS to consider.

Four of the most important areas where national agricultural research systems and networks need to improve their capacity are social science and policy, postharvest food and fiber processing, integrating natural resource management and agriculture, and providing seeds and other inputs. Any of these areas retained by regional coordinating organizations as priorities should be considered for potential SAATS funding. In these areas, SAATS should consider funding Association for Strengthening Agricultural Research in East and Central Africa to develop a startup phase of the project. The concept team expects that regional coordinating organizations should develop mechanisms to allow theme-related task forces and networks to work with commodity task forces and networks. For example, cereal processing has much in common across commodities which should be shared with each commodity network for which any results are relevant. But the critical mass necessary to make progress in cereal processing is more likely to be achieved in a postharvest food and fiber task force or network, than if scientists working on each commodity function separately. Association for Strengthening Agricultural Re-

search in East and Central Africa should be encouraged to develop coordinating mechanisms which allow commodity networks to contract with, provide grants to, or simply do memorandums of understanding which allow commodity groups and theme related groups to work together. To the extent that they are successful, Association for Strengthening Agricultural Research in East and Central Africa should be encourage to share these mechanisms with the coordinating organizations in other regions.

The thrust of the industry analyses mentioned above would be both technical and commercial. One constraint within many national agricultural research systems, networks, and Association for Strengthening Agricultural Research in East and Central Africa, to date, is the scarcity of social science capacity to consider the economic and commercial aspects of such information. One alternative SAATS should consider is support for establishiing a social science and policy task force or network to help ensure that regional coordinating organizations and national agricultural research system improve their capacity to deal with economic and commercial side of technology systems. This task force or network should work with each of the commodity networks to address questions specific to that commodity, in addition to dealing with the more general economy-wide issues. It would also play a lead role in addressing the establishment of advantageous policy and market environments for agricultural transformation. Social science/policy studies and analyses will probably require more time than one can expect task force members to contribute. Association for Strengthening Agricultural Research in East and Central Africa will have to determine whether to contract out some of these activities or establish some continuing capacity at the level of the regional secretariat.

Another priority theme is the area of post harvest technology relating to storage, processing, transformation, food science and commercialization. Opportunities for alternative products and related processing techniques or alternative marketing mechanisms have not been thoroughly explored in Africa, even for major commodities. It is the belief of the concept team that such exploration can broaden the markets for major commodities, providing a more stable demand structure which will provide incentives for increased and more stable supply. This is one of the areas which seems most likely to provide the type of breakthroughs that will transform a commodity subsector and lead to sustainable economic growth.

Developing a task force and/or a network on postharvest food and fiber processing is an alternative which the regional coordinating organizations will likely consider. SAATS should consider supporting this effort. It is not practical or efficient to try to establish a substantial postharvest initiative for each commodity separately. Commodity networks can contract with or offer grants to the postharvest network groups to do work on specific topics of interest.

Another important area is a better integration of agriculture and natural resource considerations. The present tendency to separate agriculture and natural resource management is a disservice to both. Agriculturalists are the stewards of a large percentage of the land in most countries. In most cases this land can not be conserved and made more

productive without the involvement of the whole agricultural technology system. The goal of improved natural resource management as well as agriculture must be to improve the productivity of the land as well as to conserve it. Often natural resource departments focus more on conserving the land and agricultural departments more on increasing productivity. Both branches of technology development and transfer are needed to achieve the goal, and will be more efficient if the two groups work together.

At the regional level in East Africa, it may be possible for commodity networks to contract or offer a grant organizations involved in the Highlands Initiative to help improve soil and water conservation techniques and the sustainability of commodity production. It may be possible for the Highlands Initiative to contract or offer a grant to the networks for priority highland commodities, to help improve the productivity and payoff of their soil and water conservation activities.

Another alternative that should be considered by SAATS is a task force and/or network which addresses issues related to the provision of crop seeds and other inputs. A wide range of issues need to be covered including how to produce and provide improved seed to farmers, how to ensure that appropriate short-cycle seeds are available to help with disaster mitigation, regulation of the trade and exchange of seed and other inputs across borders, how to address providing fertilizer, the effect of fertilizer subsidies in some countries, and the feasibility of exploiting, processing, and marketing local phosphate deposits.

5.5.2. Improved harmonization and coordination of regional activities

While the process will advance more rapidly in East Africa than West and Central Africa, many of the initiatives will be experimental and will likely proceed slowly. But by the end of the first three years, Association for Strengthening Agricultural Research in East and Central Africa should have identified commodity/ industrial priorities and promising technologies/investments within those priority areas. SAATS will have withdrawn backing for the networks historically supported by PARTS and this funding will be available for allocation to Association for Strengthening Agricultural Research in East and Central Africa priorities. Association for Strengthening Agricultural Research in East and Central Africa should be able to harmonize and coordinate networks to more effectively and efficiently address the priorities which have been established.

During this phase, promising technologies and investments which have been identified during startup will be moving toward fruition. This will take the form of diffusion and adoption of promising technologies or implementation of investments which have the potential to transform commodity subsectors. One can expect little widespread farm level impact from these technologies and investments during the five years of the SAATS program funding. Assessment will have to be based on indicators that technologies capable of adoption and impact are moving to farmers and other private sector technology users and that promising investments are being made. By the end of the five years one would also expect progress on the harmonization and coordination of re-

gional programs for technology systems. However, few institutions reach maturity in a five-year period, and SAATS must expect some bumps along the road to institutional maturity. Therefore, even the Association for Strengthening Agricultural Research in East and Central Africa will likely require a longer period of support to reach maturity and establish the effective and efficient coordination of regional technology systems that SAATS hopes will develop in East Africa.

It is more difficult to guess what will be the progress of West Africa during the startup phase. Much depends on how quickly a regional coordinating organization can be established and begin to function. Only at that point can SAATS begin to develop the type of program with the West and Central African organization which it has envisioned with Association for Strengthening Agricultural Research in East and Central Africa. If that is possible the continuation of the West African program can be a fairly straight forward adaptation of the East African program to West African conditions. Hopefully the lessons learned in East (and Southern) Africa will allow the West African situation to progress relatively rapidly by learning from the mistakes and successes of the other regional institutions.

5.5.3 Evaluation between phases

The SAATS program will need a mid-term evaluation to evaluate progress to date on a regional basis and the best opportunities for SAATS support during the last two years of the project. SAATS should be prepared to adjust the program at that time as a function of regional situations and opportunities which become apparent during the startup phase.

5.6. Management procedures

The present funding mechanism for PARTS sponsored networks is as follows: Funding originates in the PARTS project in AFR/SD/PSGE. The African Bureau makes an OYB transfer to the Global Bureau which is responsible for contracting and management, including evaluation. The Global Bureau provides a grant to the World Bank/CGIAR secretariat. The grant stipulates specific amounts for different budget line items for each of seven networks, and the international agricultural research center which will be accountable for the amounts granted to each network. international agricultural research centers, and the appointed network coordinators, are responsible for detailed accounting and financial management. The CGIAR secretariat provides aggregated financial reports to the Global Bureau. The REDSOs are responsible for field monitoring and helping to provide the detailed information required in response to the Development Fund for Africa. REDSO also facilitates relationships between the regional and bilateral programs. AFR remains responsible for demonstrating impact from its funding activity.

The Strengthening African Agricultural Research and Faculties of Agriculture project evaluation of May 1993 was critical of the funding and management system in that project, which was also based on joint responsibility of AFR/ARTS/FARA,

R&D/AGR/international agricultural research center and REDSO, ESA, ANR. It suggested that the REDSOs appeared to be a desirable location for the technical management and administrative oversight of regional programs. It based this conclusion on the judgement that technical management and administrative oversight should reside in the same entity and be as close as possible to the activity. It did not actually recommend that option citing tight direct hire personnel situation and problems anticipated by some in having the REDSOs directly engaged in project management. It recommended instead the use of USDA personnel rather the direct hire staff to fill positions of technical management and oversight.

The use of a direct hire REDSO personnel to manage such a program does not appear to be very feasible under present circumstances. The possibility is further complicated by the changing role of the REDSOs. REDSO personnel reported that their primary role is now technical assistance to a variety of projects and programs and that financial management is not their responsibility. Most REDSO personnel travel nearly 50 percent of the time, providing technical assistance and administrative oversight. With these standard operating procedures, it is not clear that REDSO personnel are in a position to focus on, backstop and manage a program like SAATS. They can potentially continue to do a certain amount of field monitoring to supplement the monitoring provided by the program activities and the Global Bureau.

Looking at the joint responsibility system from a slightly different angle, the PARTS evaluation of July 1994 suggests that the African Bureau should continue the use of the Global Bureau for implementation of research and analytic activities because it is an efficient and effective mechanism. It did criticize the exchange of substantive and process information between PARTS and the Global Bureau. The PARTS evaluation was also critical of the tracking, reporting and general accountability of the joint responsibility system. To help the African Bureau demonstrate the impact of its funding activity, the PARTS evaluation recommends the immediate implementation of a monitoring and evaluation system and the generation of cumulative impact results every six months. With these modifications the existing joint management system appears to provide a viable base which can be used to initiate SAATS activities.

One of the principles underlying the SAATS Initiative is the need to empower African institutions to make decisions and allocate resources for activities which are intended to serve their interests. There is a strongly expressed desire on the part of national agricultural research system and regional institutions to reduce the influence exercised by international agricultural research centers through control of the financial resources for regional activities. While the existing system to manage funds for regional networks established under PARTS is "effective and efficient," it will have to change to respond to this principle.

One alternative is to continue using the international agricultural research centers as fiduciary agents but to formally recognize the responsibility of the framework for action institutions to set priorities and allocate funds. This may serve as an interim strategy until

regional institutions develop financial management capabilities and are certified to handle funds directly. It is not a likely long-run solution because it does not fully empower African institutions, and international agricultural research centers may not be willing to accept fiduciary responsibility for funds which they do not control. This system, as presently used, has the disadvantage that a regional institution may have to work with several international agricultural research centers to receive funding for the activities which it sponsors. It is not clear whether all funding for a given regional institution can readily be channeled through a single international agricultural research center. Furthermore, if USAID is serious about empowering Africans and developing and institutionalizing management capacity, African institutions must manage their own funds.

A number of alternatives exist for achieving this change. One alternative would be to use the same basic mechanism and continue joint AFR/Global/REDSO responsibility, but have the CGIAR secretariat provide the funds directly to the regional institutions rather than to the international agricultural research centers. This does require the development of accounting and financial management capacity within the regional institutions, but that capacity is necessary for them to become viable institutions. Certification would be a constraint initially, and the project will need to use the fund transfer capacity of the international agricultural research centers until that can be established. Developing this financial management capacity will require some technical assistance, whether provided by Special Program for African Agricultural Research or directly from SAATS.

An alternative which uses existing relationships established under the World Bank multidonor umbrella would be to make the grant to the Special Program for African Agricultural Research secretariat instead of the CGIAR secretariat. This would require that the Special Program for African Agricultural Research secretariat develop and perfect mechanisms to transfer funds to the framework for action institutions and to manage and account for these funds. Given the political sensitivity to passing SAATS funding through the international agricultural research centers, this alternative would appear to be the preferable.

In this system Special Program for African Agricultural Research would appear to be the appropriate source of technical assistance to develop the financial management capacity of the regional institutions. The desirability of this alternative underlines the need to consider providing some SAATS funding to Special Program for African Agricultural Research to rapidly initiate the development of financial management and institutional capacity in the regional institutions.

A final alternative uses neither Global Bureau nor the World Bank fund transfer mechanism. It would consist of establishing a project entity which uses contractor, collaborative agreement or USDA personnel to directly manage SAATS funding to regional African research institutions. This project personnel might reside in the REDSO offices, or in a collaborating bilateral mission, which would accept some responsibility to provide support services to the contractor and administrative oversight. The need to account for every dollar to its final destination would probably require a financial man-

agement person for each regional institution, as well as the person responsible for technical management. This need to provide financial management in addition to technical management and administrative oversight would add substantially to the complexity and cost of implementing the SAATS program in this manner. Assuming that one person is needed in Washington to coordinate the overall program activities, this would imply a technical assistance team of five to seven people financed by SAATS for East and West Africa (an additional two people would be needed in Southern Africa). This would imply a technical assistance cost of between $1 million and $1.5 million a year for project management in East and West Africa, which appears very expensive in comparison with the use of the existing joint management system.

The only efficient way to gather information on activity impacts is to have each program and activity providing a summary of the impacts at each operational level in the hierarchy to the central coordinating organization. That is not to say that this will be easy, since personnel at each level of the hierarchy will need training in how to monitor and evaluate impact and use impact indicators. Since activity participants will change over time, it will be necessary to develop some capacity at the level of the regional coordinating organization and priority program to help individual activities include monitoring and evaluation of impact in their proposals. It may be necessary to have someone from the permanent secretariat of the regional coordinating organization present at meetings of priority programs to present workshops on impact monitoring and evaluation. Initially it may be necessary for REDSO to present workshops on impact monitoring and evaluation for members and staff of the regional coordinating organization and for priority programs as well. Another important role of REDSO might be to provide independent verification of the impacts cited in the reports. Reports form REDSOs might concentrate on problems, opportunities and recommendations generated from their role in administrative oversight and in verification of impacts. Their role would include administrative oversight, verification of impact reports, and consulting with regard to impact monitoring and evaluation.

The CGIAR secretariat or perhaps the Special Program for African Agricultural Research secretariat in the future would provide information to the Global Bureau concerning budgets, financial management and the results of yearly audits. Assuming that the Special Program for African Agricultural Research secretariat receives some funding from SAATS, it should report to the Global Bureau on progress to date in establishing regional coordination of programs concerning technology systems. The Special Program for African Agricultural Research definition of a successful program may differ from that of SAATS, but it is a perspective that SAATS should consider.

The role of the Global Bureau might be to collate and organize the information received from the regional coordinating organizations (including reports by each of their priority programs), the REDSOs, the audit firms, and Special Program for African Agricultural Research. They might possibly receive other inputs from the international agricultural research centers which should be included. As the managing entity the Global Bureau would have its own administrative oversight and report on its observations of

problems, opportunities and recommendations to improve progress toward the objectives which had been agreed upon. It would also fall to the Global Bureau as the managing entity to do an analysis of progress, and impacts, and proposes ways in which the program could operate more effectively or efficiently.

With these types of inputs, the African Bureau should have the information it needs to put together a report for Congress on the impacts of its funding activities.

6. Assumptions and risks

A thorough social and economic soundness analysis is beyond the scope of work for the design team. However, a discussion of assumptions and risks is appropriate. The risks this project will face may be divided into two categories: risks external to the project, which the project can monitor but cannot manage or evade; and internal risks, which the project can attempt to negate, reduce, limit, or avoid.

6.1. External risks

6.1.1. Weather

Many parts of Africa are threatened by drought, floods, and desertification, especially the first of these. A climate that allows agricultural production is an absolute requirement: no rain, no grain.

6.1.2. Politics

Civil wars not only stop projects like SAATS but may destroy prior gains. International conflicts within the SAATS regions would compound such losses.

6.1.3. Domestic buying power

The first production gains brought about by SAATS will likely impact local markets. If these economies are unable to buy these new goods, the gains will have no value.

6.1.4. International exposures

When domestic demand is met, further added production will look to foreign markets. Such production will confront the uncertainties of foreign demand, world prices, and competitive production breakthroughs, which may occur elsewhere in the world as well.

6.2. Internal risks

6.2.1. Habits and traditions

New products and accompanying research foci may call for changes in customs and attitudes, a difficult process. Clever advertising, open minds, and attractive prices will help.

6.2.2. Legislation

At a minimum, the legislation bearing on agricultural productivity and profitability should not be hostile. Policy studies, persuasion, and patience may bring improvements here.

6.2.3. Management deficiencies

The assumption of planning, research and transfer, and accountability responsibilities by local agencies, groups, and individuals will be a process involving training, technical assistance, and time; it will see the stumbles and blunders that accompany any entrepreneurial startup. These are to be monitored, accepted, and remedied where possible.

6.2.4. Winners and losers

Economic changes of the magnitude contemplated by this project improve some people's fortunes and diminish others'. In assessing activity proposals, attention will be given to this consequence in attempting to identify likely sources of support for, and opposition to, the innovations the project is about to attempt.

6.2.5. Environmental and natural resource degradation

Agricultural research and resulting knowledge and products may cause environmental damage. Each research, production, and marketing proposal will be examined on this count, and potentially destructive activities will not be funded.

6.3. Summary

All these risks are to be monitored, and if any risk or combination of risks begins to impede progress seriously in any project area (geographic, institutional, commodity, or industry), project assistance may be reduced, suspended, or terminated.

References

AFTEN, 1992. Environmental Status Report Sub-Saharan Africa. The World Bank, Africa Region, Technical Department, Environment Division.

Badiane, Ousmane. 1993. The role of agriculture and trade in economic development. *In Agricultural Restructuring in Southern Africa,* edited by Csaba Csaki, Theodor Dams, Diethelm Metzger, and Johan van Zyl.

Blase, Melvin G. *Institution Building: A Source Book.* 2d edition. Columbia, Missouri: University of Missouri Press, 1986.

Catterson, Thomas M. 1994. Integrating natural resource management concerns into agricultural research in sub-Saharan Africa. SAATS position paper.

Cleaver and Donovan. Further information not available at time of publication.

Conference of Ministers of Agriculture, East and Southern Africa, pp. 1—7. Further information not available at time of publication.

DeLattre, A., and A.M. Fell. 1984. The Club du Sahel—An experiment in international cooperation. Paris: OECD.

Johnston, Bruce F., and John W. Mellor. 1961. The role of agriculture in economic development. *American Economic Review* 51: 566–93.

Leonard, H.J. 1989. Overview—environment and the poor: Development strategies for a common agenda. *In* H.J. Leonard, editor, Environment and the poor: Development strategies for a common agenda. New Brusnwick, N.J.: Transaction Books.

Lipton, Michael. 1988. The place of agricultural research in the development of sub-Saharan Africa. *World Development* 16: 1231–57.

McClelland, p. 50. Further information not available at time of publication.

McGahey, Mike, 1994. Personal communication to Jeff Hill.

Mellor, John W. 1990. Food price policy and income distribution in low-income countries. *In* C.K. Eicher and J.M. Staatz, eds., *Agricultural Development in the Third World,* 2d ed. Baltimore: Johns Hopkins University Press.

Oram, Peter, 1991. Institutions and technological change. *In* S. Vosti, T. Reardon, and W. von Urff, eds., *Agricultural Sustainability, Growth and Poverty Alleviation: Issues and Policies.* Feldafing, Germany: Deutsche Stiftung für Internationale Entwicklung.

OTR, 1987. Plan for Supporting Natural Resources Management in Sub-Saharan Africa. Agency for International Development, Bureau for Africa, Office of Technical Resources.

Paarlberg, Robert L., 1994. Sustainable farming: a political geography. 2020 Brief 4 (Washington: IFPRI).

Pinstrup-Andersen, Per, and Rajul Pandya-Lorch, 1994. Alleviating poverty, intensifying agriculture, and effectively managing natural resources. Food, agriculture and the environment discussion paper 1 (Washington: IFPRI).

Plucknett, Donald L., Nigel J.H. Smith, and Salcuk Ozzedig. 1990. *Networking in International Agricultural Research.* Ithaca, New York: Cornell University Press.

Schuh, G. Edward. 1990. Technical Change: Sources of Income and Agricultural Production in Developing Countries. *In* National Research Council, Board on Agriculture, *Technology and Agricultural Policy.* Washington, D.C.: National Academy Press.

Schultz, T.W. 1980. Nobel lecture: The economics of being poor. *Journal of Political Economy* 88: 639–51.

Staatz, John M., 1994. The strategic role of food and agricultural systems in fighting hunger through fostering sustainable economic growth. Michigan State University, Department of Agricultural Economics, Staff Paper 94-39.

Special Program for African Agricultural Research, 1994. Further information not available at time of publication.

Timmer, C. Peter, 1990. The agricultural transformation. *In* C.K. Eicher and J.M. Staatz, eds., *Agricultural Development in the Third World,* 2d ed. Baltimore, Md.: Johns Hopkins University Press.

Timmer, C. Peter. 1994. Further information not available at time of publication.

Tinsley, R.L. 1994. Rice Production. SAATS Position Paper.

von Braun, Joachim, and E. Kennedy, 1994. Agricultural commercialization, economic development and nutrition. IFPRI Food Policy Statement # 19 (August).

Weber, Michael T., J.M. Staatz, J.S. Holtzman, E.W. Crawford, and R.H. Bernsten. 1988. Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue. *American (Journal of Agricultural Economics.* pp. 1044–52.

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Postharvest loss reduction and sustainable processing technology position paper

by

Robert P. Maloney

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Executive summary

During the past two decades two areas of agricultural research which have received attention and support from donor agencies are postharvest loss reduction and agricultural processing technology transfer.

Postharvest loss reduction gained impetus in the late 1970's by a United Nations resolution to reduce postharvest losses by at least 50 percent by 1985. This savings would greatly assist in feeding the world's hungry.

The goal was not achieved, but there were sufficient successes to demonstrate the effectiveness of technological intervention.

Loss reduction assessment, while having lost its stature, is a vital factor in the analysis of commodity systems where the return on inputs, technological or other, must be quantified.

As technology became a major component in development programs, and the need to introduce technology in the face of constraints and resistances became apparent, technology transfer developed as a discipline.

Experience in agricultural technology transfer has demonstrated that success in agricultural development depends on an ability to receive, utilize, and sustain the growth induced by the technology. There have been many successes, but there is doubt as to the sustainability of the successes.

Processing technology is one component of a commodity system and is interrelated with all other components of the system. An ability must be developed in those who are in the commodity systems to understand that system as a series of inter-related and interdependent functions.

Failure to understand the impact that a technological intervention may have on various parts of the system to which it is introduced may limit the success of the intervention.

People, technicians, managers and policy makers, not technology determine how a system will function and if changes introduced will lead to sustained growth. These technicians managers and policy makers must be trained and educated to reduce obstacles to sustainability of agricultural growth.

For sustainability to be realized, there must be mechanisms developed to support agricultural research and development. Successful models exist and consideration should be given to the adaptation of the programs to national agricultural programs.

There are numerous potential microenterprise opportunities in the staple crops and nontradi-

tional crops of Southern Africa. Some of these are mentioned in this paper, mainly as a means of demonstrating what is required to develop and sustain microenterprises.

Production technology and assistance is generally available and of good quality. Knowledge about processing technologies is available and some institutions provide assistance to potential users of the technology.

An area that is deficient within the production/marketing system is the business management and marketing capability needed to successfully compete in the system. There is a lack of assistance to the potential entrepreneur both prior to and during the development of an enterprise.

Research institutions could play a valuable role in microenterprise development in Southern African nations if the ability to provide technical assistance in business development and management as well as technical assistance in processing became an on-going function of the institution.

Postharvest loss reduction and sustainable processing technology

Research activities throughout the developing world have made tremendous strides in increasing agricultural production through development of new production technologies. The potential contributions of these research activities have not been fully realized due to constraints or resistances to their adoption or an inability of small entrepreneurs to be able to develop and manage microenterprises based on research developments and other local opportunities.

The overall objective of research has been to increase the food supply and the economic condition of small farmers and the benefits that accrue from the improved economic condition of the farmers. Agricultural technology transfer and development has had a positive impact on several African nations. The need still exists, however, to develop for individual subsectors or commodity systems to establish the ability to sustain these advances, generate new contributions or respond to new opportunities.

Two areas of research and extension activity that have received particular attention and funding in the past two decades are postharvest loss reduction and appropriate agricultural technology. These activities were seen as complementary to advances in production technology and had merit in their own right as contributing to the economic well-being of farmers in developing nations. The reduction of postharvest losses was seen mainly as a technological problem and the "appropriateness" of the technology became an issue in loss reduction.

In the 1980's a new discipline developed within the various fields of agricultural science and social studies known as "technology transfer." Horticulturists, agricultural engineers, agronomists, sociologists and anthropologists, and others discuss and publish articles, books and essays on the need and methodologies of transferring technology to clients in agricultural economies both developed and developing.

In this paper the focus is on technology development and transfer as it relates to the business opportunities of processing or handling of produce after harvest. It is stressed, however, that it is understood that there are relationships both direct and indirect between the activities in production and the ability to efficiently move a commodity through the postharvest system to the ultimate consumer.

Processing and postharvest technology development and transfer, which gained impetus and credibility from postharvest food loss—reduction activities, must be market—oriented and sustainable.

To accomplish this, the relationship between technological intervention and socioeconomic factors within the production/marketing system must be analyzed for their impact on potential long-term, sustainable, benefits from these interventions.

The analyses should provide some guidelines for an efficient use of resources for the development of a sustainable capability for agricultural development.

Postharvest loss reduction initiatives were the first large-scale activities in the area of technological intervention in postharvest processing and handling. Postharvest food loss reduction has laid an invaluable groundwork for understanding the implementation of technological interventions

Postharvest food loss reduction

In the 1970's concern arose about the losses of food in the world's agricultural systems and the contribution the gains received by reduction in losses of these foods could make toward the alleviation of world hunger.

In 1975 the United Nations General Assembly passed a resolution that "the further reduction of food losses in developing countries should be undertaken as a matter of priority, with a view to reaching at least a 50 per cent reduction by 1985." (1)

According to Greeley (2), "There were three unquestioned assumptions: that food losses were high; that they could be prevented cost effectively; and that there would be less hunger as a consequence."

Postharvest losses were assumed to exist at high in nearly all farming systems. This assumption, though often correct, was variable; the exact extent of losses was unknown. Loss studies and estimates presented data which, though not precise, gave impetus to the investment in programs designed to reduce postharvest losses.

Although there has been no doubt about the existence of food losses, the quantification of these losses has been poor and inadequate for purposes of designing a cost-effective program for their reduction. As will be discussed, without reliable figures the design and implementation of a cost-effective loss reduction program is not possible.

There has been, and continues to be, controversy as to the reliability of data on losses, methodology of quantifying losses and manipulation of loss figures. Bourne (3), speaking of losses in South East Asia, states that "figures that have been obtained by careful measurement are manipulated for various reasons." This is not to imply that all loss estimates are incorrect or manipulated, but very few researchers have developed figures which can be considered reliable and replicable.

Miracle (4) discusses maize losses in various tropical African areas of eight countries and concludes that storage losses, often considered to be a principle source of losses, range from 1 to 2 percent. He concludes that "available evidence suggests, then, that storage losses are low

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enough with the techniques currently employed for changing storage techniques to deserve low priority, if any, in development programs." Miracle goes on to say that potential gains can be made in the processing of maize through mechanization with resulting savings in labor. This, however is not loss reduction. The chief reason that loss estimates are often unreliable are the methodologies developed to assess losses and the difficulty in conducting loss surveys. Bias, based on a need to have sufficient losses to be able to justify a loss reduction program and/or the introduction of technology, also adversely affects some results.

Methodologies to assess postharvest losses are extremely difficult to design and very complex when their design does prove to be adequate. This complexity translates to a need for users of the methodology to have interdisciplinary skills to evaluate not only the losses, but also the social and economic effects of the proposed technological interventions

Programs aimed at loss prevention almost always advance the idea that technological intervention is necessary to prevent losses within a commodity system. The results of the "green revolution" in which the investment to achieve increases in productivity through technology led to returns several times greater than the investment lent credence to the idea that loss prevention could be accomplished through technological inputs.

Greeley, speaking of loss estimates in the Philippines, concludes that, "the direction of R&D initiatives (was) towards technical research designed to prevent loss rather than towards analysis of the size of loss and the costs and benefits of loss prevention. Technological determinism, the HYV seeds, aid dependence and commercial interests all contributed towards this research bias."

With a bias toward technology, single discipline rather than interdisciplinary research was conducted and solutions were developed without a full understanding of the nature of losses and the consequences of different methods of preventing the losses. The results of postharvest loss prevention programs has not been the success aspired to when the U.N. passed their resolution to reduce postharvest losses by at least 50 percent by 1985.

Social and economic considerations in loss reduction

Loss prevention, or loss reduction which is perhaps a preferable term considering that losses will never be totally eliminated, is a worthwhile objective but there are some important economic and social considerations in reducing these losses.

Most loss reduction programs are aimed at the farm level activities where, with the exception of market losses discussed later, most losses occur. Greeley (9) writes that "Preoccupation with loss prevention carries the implicit assumption that the neglect of the issue of food loss has been shared by farmers also. He outlines ten considerations about technical change at the farm (briefly paraphrased as follows).

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a. Traditional postharvest techniques have very low levels of capital and are labor-intensive. Any technical change will be labor-reducing.

b. Technical change that always reduces losses is inherently risk-reducing, unlike production investments such as hybrid seed which increase the degree of uncertainty as to the return on the investment. This gives postharvest loss technology an advantage that is lost when losses are variable throughout the system.

c. Reduction of losses at the farm level may increase the period of self-sufficiency and thereby reduce expenditures on consumption loans or market purchase at a time when the cost of the food is expensive to obtain. If the consumption shortfall was previously met by eating less or inferior food, the argument is that the monetary benefits will be less, but nutritional status will be improved.

d. The realization of economic returns from the market will depend on the sensitivity of markets to the quality of grain. The perceived value of quality in the market or markets where the grain will be sold may influence prices and the resulting economic returns to the grower.

e. Access to cash constrains the ability of many farmers to invest in loss-reducing technologies. The cost of transactions to obtain cash may be greater than the returns from the loss-reducing investment.

f. If the introduction of loss-reducing technology is labor-reducing (as it normally is) it is important to consider who is being displaced and whether alternative employment is available for those displaced. The example used is that of landless women in Bangladesh for whom nonfamily employment does not exist.

   Family labor that a farmer is obligated to employ may be overvalued. A reduction in their labor effort may not be immediately beneficial to the farmer.

   Some technologies lessen the total labor demand but may increase the time-specific labor. This could result in the need to hire labor which would ordinarily be accomplished by family or permanent hired labor.

g. Loss reduction may not have the priority of other economic activities. Using tractors to plough the next crop may be more important to the farmer than using it to thresh harvested crops. The farmer may lose part of his crop to mold and germinate—a loss not due to neglect, but to the farmer's perception of the greatest return on his assets.

h. The farmer is a business manager and as such must make decisions as to the most productive use of his time and resources. His management decisions may result in postharvest losses. The example used is the loss of untreated harvested rice which may be lost because of the urgency to plant the next crop in time.

i. When the perceived risk of postharvest losses is high the farmer may sell off his crop his unprocessed crop (and buy back consumption needs) rather than invest in loss reducing technology. This is a frequent occurrence with hybrid varieties which are known to be difficult to store.

Sometimes a standing crop is sold prior to harvest and the farmer rids himself of all postharvest responsibilities. The decision to invest or not invest in postharvest technology is complex and each farmer will consider the trade-offs in when to sell the crop.

j. Postharvest losses vary from farm to farm and real and perceived losses of one farmer may not be same as another in the same region. Adoption of technologies to reduce losses may depend on available credit and the innovativeness of the farmer. Some farmers are quicker to adopt technology than others. Other factors, such as the consideration of the technology as a status symbol, may influence other farmers to invest.

As Greeley points out, "accurate assessment of farm-level postharvest loss prevention intervention prospects is a complex matter. Even seemingly advantageous characteristics such as risk-reduction and benefits accruing in the lean season have been seen to require substantive qualification. Together, they represent a serious challenge to postharvest orthodoxy which, however well motivated, has advocated technical solutions without serious analysis of their economic merit."

Postharvest losses occur at the on-farm and off-farm levels. Storage capabilities of markets are often pooer in markets than on the farm. Supplies received in a market are expected to be sold in a specific time period. Volumes received are normally calculated to not exceed the ability to temporarily store that volume.

Short-term gains from loss-reduction may not be realized if there is no ability to store the additional volumes without incurring losses.

This is one of proably many considerations necessary when contemplating the feasibility of loss prevention technology.

There are many on-farm and off-farm considerations which must be made when considering the introduction of loss-reducing technologies. The question that one should ask is, can a researcher from a single discipline adequately consider all the complexities involved in reducing losses?

Schemerhorn, et al. (5) discuss some of these considerations which include the question as to the effect of the increased production on prices in the local or regional markets. Have those who propose the reduction in losses considered the elasticity of demand and the potential effect of increased volumes of the commodity on prices?

A study of potato demand in Jamaica concluded that the marketing of potatoes saved due to a

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5 percent reduction in losses would result in a 10 reduction in prices. A similar reduction in tomato losses in Egypt where there is an overabundance of tomatoes, would result in a 12 percent reduction in local market prices (6).

Obviously, these price reductions are unacceptable to all those in the marketing system, but especially to those who would have to make the investment of resources to accomplish the reduction of losses. This does not mean that postharvest loss reduction in these crops should not be attempted. As discussed later, there is a rationale for employing loss-reducing techniques.

Another question on reducing losses is whether the one who reduces losses is the one who benefits from the increased returns. If, for example, a point of losses is determined to be during transportation from the farm to the market, will the changes be made if there is a cost to the trucker which cannot be recovered? This depends on the circumstances of the trucker, but in ordinary situations the trucker will not invest any money for which there is no return.

For any investment to be made in loss prevention technology there must be a return realized by the investor that is greater than the costs of that technology. No one in the postharvest/ marketing system can be expected to invest in the reduction of processing or postharvest losses if they are not convinced they will receive a return on their investment.

This brings us to the principle problem in the application of technology to the reduction of losses—the inadequacy of methods of quantifying losses. Consider the following data for rice losses reported for West Africa (7):

Point of loss	Percentage of loss
Drying	1–2
On-farm storage	2–10
Parboiling	1–2
Milling	2–10

If a decision must be made about an intervention to reduce losses based on these figures, a case can be made for intervention if the losses in storage and milling are 10 percent. At losses of 1 to 2 percent in drying and milling no technological intervention is justified. Perhaps some changes can be made in the way the crop is dried or milled but the cost(s) of an investment in technology would be very hard to justify. A 10 percent loss is unacceptable and the reduction of such a percentage can reasonably be expected to be accomplished cost-effectively through an investment in technology.

However, if an investment is to be made, a reliable loss figure must be available to the person calculating the costs and returns on the potential investment in the necessary loss-reducing technology. The returns to the capital invested must be greater than would be obtained from the investment of the same capital in another venture.

Returns on investment may be based solely on savings derived from the market value of the product saved or it may include the value of labor which is reduced or returns from activities such as custom hire use of the technology.

Regardless of what income or savings are generated, loss assessment figures must be precise.

Experience in loss assessment has demonstrated that within any commodity system there are losses. These assessments are rarely precise and the validity of the results of many studies are debatable. However, loss assessment as part of a project or program aimed at improving economic returns in a subsector of a national economy is usually necessary.

Specific loss reduction assessment to complement a project or program design, as opposed to general loss assessment studies can be more easily accomplished given the narrower focus required.

Qualitative benefits from loss reduction

Loss-reduction technology does not necessarily only result in quantitative improvements, but also in qualitative improvements. As an example, tomatoes in Egypt are over-produced; losses of fresh-market tomatoes are estimated to be 15 percent to 30 percent (8). Some researchers say that there is no loss, since even the poorest quality (rotten and rotting) tomatoes have a market with the lowest income people.

Quality is differentiated in the marketplace, albeit, informally. Farmers or vendors selling to wholesalers can receive up to a 20 premium over the market price for quality. Some quality attributes have nothing to do with factors relating to losses. Uniformity of pack is rewarded and is not associated with losses. Damaged tomatoes are purchased at a price lower than the prevailing market price because of the potential for loss in the market and the home. Some growers have found that costs of reduction of damage (potential losses) through careful packaging and handling are cost-effective.

Social benefits are gained from this loss-reduction/quality improvement activity. If the general quality is improved the tomatoes available to the low-income consumer should be more wholesome and have greater nutritive value.

Another social consideration in the reduction of postharvest losses is that in Greeley's point (a) above about the displacement of women by technology. The role of women in farm labor needs to be considered when alternative technologies are considered. In some instances the

women may be freed to perform other necessary tasks, in others the need to hire outside laborers may increase costs.

Further, the role of women in the decision-making of the family farm must be considered in any attempt to introduce change to a farming system.

Women not only contribute to the labor in agricultural families, but are often responsible for certain of the processing activities. Women are decision-makers in some rural societies.

Proposed introduction of loss-reducing technology must consider the role of women in the farming system, the effect of the changes on their activities and economic well-being, and very importantly, involve them in the decision-making process.

Recommendations

Given the complexities and discrepancies of the results of postharvest loss studies it would be easy enough to say; forget the loss studies, we know the losses exist, let's get on with reducing the losses. The reality is that we must have reliable quantification of losses.

Project analysis requires precise quantification of results. Without reliable baseline data it is impossible to measure what has been accomplished, what the rate of return on investment has been.

From an economic point of view, an accurate quantification of losses is a requisite for a cost-benefit analysis of any investment being considered to reduce losses.

Loss reduction must be assessed within the context of a specific system—that system through which specific production flows from field to consumer. Generalized loss studies have very limited use and provide very little return on the investment to carry them out.

Loss assessments must be generated by a need to know their quantity for use as a factor in establishing the cost effectiveness of planned technological interventions in a production-marketing system. The assessment must consist of a series of quantifications at several points in the system. Additionally, there may be qualifications that are determined to have an impact on the suitability or viability of planned technological intervention.

As has been mentioned previously, it is unlikely that a person or persons from a single discipline will have the range of knowledge to fully analyze all the variables involved in the quantification and qualification of losses. This is not to say that it cannot be accomplished. There are professionals who have years of interdisciplinary experience who might satisfactorily accomplish the task, but developing a sustainable ability to assess losses in the context of African research precludes their consideration.

To determine losses and recommend technical alternatives, the ideal postharvest loss researcher would be part postharvest physiologist, part engineer, part agri-business specialist/ economist and part cultural anthropologist.

The alternative is to develop a team within a research program that is comprised of professionals who have the combined ability to consider all the socioeconomic implications of losses and their reduction through technological innovation.

Ideally, there needs to be a coordinator of such a team. Proponents from any discipline could make a convincing argument that the coordinator should be from their discipline. Ideally, the coordinator should have a multidisciplinary background, if not in terms of academic credentials in all areas, then at least in practical experience.

If a team cannot be assembled to carry out the task of loss assessment, a review board or team should be set up to evaluate the results of the research prior to introduction or implementation of recommended technology. All resources available, including efforts and results of similar programs in other locations should be used to evaluate losses and their reduction.

Information exists at various institutions which in these days of electronic should be available to all research institutions. Limited manpower and scarce resources make the investment in this technology cost effective and in many instances invaluable in terms of time and ability required to duplicate research already published.

University programs at the graduate level are designed to train a student in a single discipline, with occasional interdisciplinary programs of two complementary fields of study.

Most often a student will specialize in a major subject. The result is often a graduate with very specialized ability in a single field who, as a graduate postharvest physiologist, for example, is expected to handle a postharvest loss program with a knowledge limited to the physiology of plants and no experience outside the classroom.

Consideration must be given to the development of educational programs in U.S. universities for research professionals that provide the professional with a more varied and useful background in the sciences and provide the opportunity to gain practical experience in the field.

Sustainable processing and postharvest technology transfer

There have been significant advances in food processing and postharvest technology in developing nations in the past two decades. The economic results obtained have established the value of technological intervention in economic development.

Technology development and transfer is critical for the continued development of the agricultural sectors of developing countries. New opportunities and markets are becoming acces-

sible to many agricultural economies, new, higher yielding varieties of commodities are constantly being developed. However, hunger and malnutrition continue to be serious problems.

Limited resources to respond to all present and future demands of technology in agricultural economies requires that, within nations or regions, a capability to respond to on-going technological needs be developed in order that the most profitable use of resources are realized.

Constraints to Technology Transfer

The constraints and difficulties of technology transfer are as complex as the systems into which they are being introduced.

Technology transfer is a discipline based on improvements in the strategies developed by research and extension professionals. These strategies are strengthened by inputs from research on "information diffusion and adoption, interpersonal communication, mass media impact, group process, and systems of doing research and extending the findings to users."

The challenge of technology transfer can be taken a step beyond the ability required of the transfer agent to include the ability of the client to receive, use, develop and manage the technology.

Ruttan writes, "The capacity to develop and to manage technology in a manner consistent with a nation's physical and cultural endowments is the single most important variable accounting for differences in agricultural productivity among nations." (12)

Development projects have had varying success. Poor project design, poor implementation, inappropriate technology, failure to understand the local customs and attitudes, and other reasons, ad infinitum, have been held responsible for instances of lack of success.

Of the factors causing lack of success in technology transfer, Madu (13) states, "The MNCs (multinational corporations) are often blamed for not facilitating the transfer process. However, internal factors and poor planning on the part of the receiving country also contribute to the failures of technology transfer."

This holds true for not only MNCs but also for development projects. Anyone who has been involved in project implementation in a developing nation has, at one time or another, been asked, 'who will carry-on what you have begun?

Others have been unfortunate enough to find that there was no one really capable of receiving and utilizing the available technology. Worse, perhaps is the realization after arrival in a country that the project has little or no relationship to short or long term goals or that such goals do not exist.

Madu (14) goes on to say that, "The success or failure of technology transfer also depends on the ability of the receiving nation to identify the right technology for its needs."

Madu is mainly concerned with industrial technology transfer and develops the need for managers to manage not only in the conventional sense, but also to be able to manage change and meet future challenges.

Agricultural research systems, while not in a league, perhaps, with multinational corporations have, at their own level, similar problems. Managers of research and agricultural development programs must also be capable of managing their programs much in the much the same way that industry manages its programs.

The management of agricultural research programs may not be as competitively demanding as management of an multi-national corporation, but it is certainly more complex.

There are probably many "managers" of agricultural development at many levels who would like to be relieved of the burden of social costs and benefits in their calculations as to the most productive use of available resources.

Until this ability exists, or while it is being developed in developing countries, technology transfer must be accomplished in a manner that encourages and develops the needed management and planning expertise.

While the effort is being made to enable policy-makers and decision-makers in the various institutions to be able strategically plan agricultural development programs, existing systems and programs must be supported and improved through the transfer and development of technology.

The commodity system

All commodities exist within, and flow through a system. The basic system is composed of production, postharvest and marketing. Each of these broad components is interrelated to each of the other components.

Technical interventions on any one part of the system can be expected to have an affect on other parts of a system.

A new hybrid variety of corn may require different storage techniques, or handling in the marketplace.

Integrated Pest Management in production may require adjustments to pest-resistant varieties which have handling and marketing characteristics different from previously produced varieties.

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Consumers' demands may be for a vine-ripe tomato instead of a mature green tomato that has been harvested mature-green and ripened by gas. This would normally imply adjustments in production and especially in postharvest handling to adjust to the postharvest needs of the product.

Adjustments within the basic components are normally necessary when one of the technical activities of the component is affected by an intervention. In postharvest handling of tomatoes, for example, the following technical activities take place:

Harvesting,
Field handling,
Transportation to the packing facility,
Sorting and packing operations,
Cooling,
Transportation to market,
Cold storage (short-term),
Ripening,
Distribution and retail handling
Handling by the consumer.

If, as was mentioned above, a grower decides to respond to market demand for a vine-ripened tomato, adjustments have to be made throughout the system:

- Laborers must learn to harvest at the correct stage of ripeness.
- Field handling and transportation most likely must be improved to handle more delicate tomatoes.
- Equipment and selection adjustments must be made to sort and pack riper tomatoes.
- Prompt and proper cooling is more critical with riper tomatoes.
- Transporting riper tomatoes, which have a shorter shelf-life requires very reliable transportation.
- By definition, the tomatoes do not need to be ripened, but good storage is critical.
- Temperature maintenance and careful handling during distribution become more important.
- The retailer and the consumer need to learn how to handle a riper tomato.

In order for the commodity system to function properly, *information* must be available that quantifies what has occurred, is occurring, and most likely will occur to the commodity

volumes and price at any point in the system. This information must be reliable, timely and useful.

Strategic planning for research, production, processing and marketing requires this information, not only for the producing country, but also for other countries producing the same or competitive products and the markets in which these products are sold.

Information or knowledge must be available to those who function within a commodity system about the technology of the commodity. The body of existing knowledge for most commodities is great and growing constantly. Access to this knowledge is vital to the ability to handle technological change.

The change agent—client system

Technology transfer implies that there is a client or clients who will receive the technology. In some cases there is one or a few clients. In other cases, such as in the introduction of a new variety of corn, the client farmers may number in the thousands. The introduction of the new variety requires some form of organization that allows the agent to interact with the clients.

Agricultural change agents are the link between research and production. Their role in providing research with information on the needs of the farmer and the farmer with applicable research findings is crucial to the smooth functioning of both the research and the production systems.

The agricultural change agent is not always an extension agent, farm advisor or other local agent. The agent may be external to the system, but local agents are usually a principle contact or even counterpart, to external change agents.

External change agents come into a system with knowledge or information to impart to that system. The contacts made who will be the intermediaries between the external agent and the participants in the production/marketing system.

It is critical that the external agent be able to communicate with the local agent and equally important that local agent be able to understand and communicate the knowledge or information to the farming community.

The change agent works within one or more commodity systems. This implies that the local change agent must be knowledgeable, not only in his field of expertise but in the relationship of technological change throughout the commodity system.

Training and education of agents who work at the farm level must create in the agents an ability to fully understand new technology and communicate with the farmer and the researcher.

This normally requires training and education that is developed to create a "generalist" who can relate to the various effects of the new technology which is being introduced.

For example, a new mill may be planned and an engineer may be sent to do a feasibility study. The engineer may need to know estimated volumes of grain to be milled, availability of electricity, storage capability, seasonality of production, costs of inputs, and various other data and information.

The change agent does not necessarily need to know this, but he must be able to communicate intelligently with those who do have the information. Likewise, the agent must be able to communicate information and knowledge obtained from the engineer to those who will have a responsibility toward the new technology. One way of gaining or developing this ability is through practical experience.

If a change agent comes from a relatively sophisticated agricultural background, one that involved participation in the production/marketing system, the training requirements will be less than if the agent has no agricultural background.

Training programs should be tailored to provide practical experience to those who need it, in as many of the sectors or components of the commodity system as required to enable the agent to function intelligently in his role and continue to learn.

Intern or apprentice programs where an agent learns while actually working in various activities are an excellent to classroom activities. The classroom activities should provide the theory and basic knowledge a trainee needs to understand how and why activities in the field are carried out as they are.

Ideally, the internship or on-the-job training should be in the private sector. It is very important that change agents learn the principles of business management and economics so a fundamental knowledge, at least, can be obtained of the economic impact of technological or social change.

Management development

The management of agricultural research and development programs requires an ability to maintain a program that is responsive to current agricultural problems and which is sensitive to the needs of the environment and the agricultural community. The manager must also be able to anticipate what future needs and problems will be and be capable of making adjustments without disrupting the functioning of the program.

The individuals most valued by research and extension departments and organizations for management are those who have a solid academic background with varied practical experience both in the public and private sectors.

In the area of postharvest extension, the most respected, and sought after of the of the "agents" for management positions are those who have had either employment with, or extensive personal contact with the private sector.

Private sector experience enables managers/agents to relate to the private sector in terms of costs and benefits and also apply this and other private sector management skills to their institution.

Policy-makers and decision-makers who are not part of the agricultural research system must be aware of the problems and the reasons behind the investments which must be made to develop solutions. Someone once said, "The problem of teaching is two-fold; first to know and then to relate." The ability to relate requires that both parties have a similar understanding of what is discussed.

In some way policy makers must be made conversant in the activities of agricultural research and development.

An example of the impact of private sector experience on agricultural technological development is the fresh produce export sector of Chile.

The agricultural entrepreneurs in Chile, through an effective exchange program with the University of California and through active participation in California agriculture, developed an ability to transfer the technology and management skills acquired to the Chilean agricultural sector.

Supportive research was developed in the Chilean university system from which the agricultural sector could receive the technical assistance needed for efficient, competitive export production.

Fundación Chile (Chile Foundation) was developed to provide information needed by participants in the export sector and promote Chilean products in export markets.

Chile should serve as a model, not only for export development but for local or regional development. The key is to develop skilled management for research or production for all sectors of the research/production/marketing system and provide the support needed by the managers for sustained growth.

Linkages with sources of information and knowledge should be developed and utilized. Two institutions which are under-utilized are the Postharvest Institute for Perishables at the University of Idaho and the Feed and Food Grains Institute at Kansas State University. These institutes were developed to provide a body of knowledge to developing agricultural systems. An effort should be made to utilize this resource and incorporate them into the information system of agricultural research and development programs.

There is an on-going debate in the U.S. university system as to the amount funding to be spent on "basic" as opposed to "applied" research. The research systems involved in processing and postharvest research in developing nations normally cannot afford the luxury of very much basic research. In most cases, given the level of technological development, the funding available is better spent on applied research for problem-solving and establishing linkages with appropriate research centers for information on basic research.

Commercial institutions

The establishment of an organization such as Fundación Chile usually requires public sector funding for some time until a credibility or utility of the organization is perceived by those who benefit from it to the extent that they will support it financially.

In El Salvador, the private agricultural and industrial sectors proposed the creation of a foundation supported by the private sector and USAID to provide development assistance, technology, information and promotion to the private sector. The USAID assistance was limited to a certain time period after which the organization, FUSAD ES, was to be self-supporting.

Today, through the development of income generating laboratory services, remuneration for technical assistance, and continued private sector support, FUSADES plays an important role in the development of the economic and social development of El Salvador.

An additional, but uncontemplated contribution of FUSADES has been to generate a number of managers for the private sector in El Salvador.

Another type of organization which contributes to the commodity sector from which it is developed is the commodity board. These organizations are supported by grower-members, usually by dues or assessments. Their basic purposes are to promote the commodity, fund research for the commodity which is beneficial to the commodity sector, and lobby on behalf of the members.

Models for developing organizations capable of contributing to sustained growth exist. These should be considered for adoption or adaptation by local or regional research and development programs and the agricultural sectors which would benefit from this type of organization.

Processing microenterprise development

Increases in agricultural production through the efforts of research can result in increases in income to the farm family, entrepreneur or farmers' organization. However, the returns to production are most often not as great as the returns on processing and marketing the increased production. As Peter Drucker says, "It is better to own the market than the factory."

The concepts of "value-added" and "vertical integration" are basic to successful agri-business. In the produce industry some of those who were regarded as "grower/shippers" are now "marketing firms;" large grain, potato and poultry operations have not only become vertically integrated in the production and marketing of their basic product, they have also moved into the production and marketing of "by-products" and the manufacture of equipment and materials related to their industrial needs.

On a micro level, this same strategy is valid for small farmers. Opportunities exist for the small farmer, either singly or as a member of an organization, to participate beyond the production level with his crop or crops and realize an increase in income.

Opportunities vary from one country to another depending on the staple crops and how they are used by the consumer, marketing structures, government pricing and marketing policies, consumer demand, availability of electric power, transportation and materials for the processing activities. In most rural areas the small farmer or group of farmers will need access to some form of financing. This is only a partial list of factors which must be considered when determining the potential for microenterprises. These few factors are meant to point out the complexity in developing potential small agri-business ventures.

Of critical importance is the availability of technical/business assistance to the small farmer(s). Most small farmers are not business people. They do not have the skills required to move from being a subsistence farmer to a processor/marketer who must have at least a rudimentary knowledge of costs and benefits. The skills needed by a farmer to be a businessperson can be acquired. Any program that intends to develop a sustainable participant in the production/marketing system of a small farmer must be certain that some program is in place to provide the farmer with the required business skills.

Processing costs

If a small farmer is to be economically successful, he or she must control costs. Basic to this control is increased efficiency of production to reduce as much as possible the cost per unit of production. Research organizations in most African nations are dedicated to this and, for most crops, the ability to increase small-farm production through improved varieties or cultivation methods has been developed.

There is a cost of production per unit of a food crop and a market price for the same unit as a processed product. The difference between the value of the harvested, unprocessed crop and the market value of the processed product determine what processing and marketing costs can be absorbed and provide a fair return on the farmer's investment. This may seem to be elementary, but is too often not fully considered when proposals are made to engage the small farmer in processing activities.

If, as an example, a small maize grower decided to enter the business of milling maize meal for sale on the local urban market, there would be certain cost considerations that would enter

into that business. Those cost concerns include the following items:

a. The cost (and availability) of maize by the grower's own production and that purchased from others, including transportation costs.

b. The purchase cost of a mill, including financing costs, if any.

c. The operating, maintenance and depreciation or replacement costs of the mill.

d. The throughput volume of maize required to optimize the production of the mill.

e. The value of losses that are nonrecoverable or the value of residual product that can be sold as feed for animals.

f. Costs and availability of energy.

g. Labor costs, taking into consideration the value of any alternative incomes.

h. The rental of, or value of, space for the milling activities.

i. The costs of licenses, permits or other fees.

j. Costs of drying, if necessary, and storage, (if required to assure a volume of raw material for processing when demand is high).

k. Packaging materials costs.

l. Transportation to market.

These cost factors must be considered in the development of a business plan and do not include the additional need for management and organizational skills that are rqeuired regardless of the level or size of the business.

Most small farmers do not fully understand all that is required of them to participate beyond the farmgate with their product. Their ability to understand that they are not prepared to participate in processing and marketing activities has very often created resistances to participation in this system.

In general, all small farmers have an innate ability to understand basic economics as they apply to their situation. Some small farmers' abilities can be expanded and they can be developed into entrepreneurs, others cannot. With those who have the interest, the business capability must be developed through education and training so they can take advantage of processing opportunities.

Developing the ability in small farmers to take advantage of microenterprise processing opportunities is possible within the framework of a national or regional research program. How this can be accomplished is discussed later in this paper.

Microenterprise processing opportunities

1. Maize:

Maize is one of the most common staple foods in Southern Africa and is produced in all countries in the region. The consumption of maize, as "green maize," whole kernel, flour, or meal varies from country to country and within countries.

There are several postharvest activities of maize that present microenterprise opportunities, either singly or as a series of activities which may be vertically integrated.

Storage. Maize can be stored either on the cob or shelled as whole grain. If maize is grown in a region where there is high relative humidity at harvest, storage is normally on the cob, sometimes in the field turned downward on the plant or hung in the rafters of the home. Storage is normally in cribs or specially designed structures. In most structures heat can be employed to dry the maize and sometimes smoke can be used to repel insects which can cause serious losses.

Techniques exist that have been developed for artificially drying maize in regions where the relative humidity is too high to achieve the 12–13 percent required for storage in bulk. All artificial drying in humid conditions requires energy use. A maize dryer used in West Africa known as the Brook type (14) uses firewood and maize cobs. The cost and availability of firewood or other fuel is the critical factor in this and other drying techniques.

If, as mentioned in the example of costs in milling maize above (j), a miller requires stocks of maize for future processing or if someone wishes to speculate on the maize market, artificially drying maize may be economical.

Prices are usually lowest for any commodity at harvest time. Regional climatic variations can create normal high demands which may make the purchase and drying/storage of maize for sale on a future market a viable enterprise.

In regions where the relative humidity is low enough to allow for proper drying of the maize, purchase and storage for speculation may be a good business venture.

Storage of one's maize or purchase of the grain for storage requires a good knowledge of historical prices, communications with the markets, an ability to meet quality and packaging requirements and the means to transport the grain to the market at the required time.

Milling. The mechanical milling of dry maize on a small scale at the village level is common

in Africa. There are hand-operated plate mills, as well as engine powered hammer mills. Industrial millers normally use roller mills that produce a more highly refined meal and have a much higher output than hammer mills.

Small-scale millers normally use hammer mills to produce meal. These mills produce a coarser product but have a considerably higher extraction rate than the roller mills.

The products of milling for human consumption are coarse meal, fine meal or flour and grits. Preferences for coarse or fine meal vary from country to country and within each country. Coarse meal is the generally consumed form of maize meal in rural areas.

In a study carried out in Zimbabwe, Jayne and Rubey (15) indicate that in spite of what is considered a "truism" that the urban consumers of Southern Africa strongly prefer a highly refined meal, a strong urban market does exist for coarse meal which could be supplied by small-scale millers with currently under-utilized hammer mills. The hammer mills are currently under-utilized due to government policy restrictions on milling operations.

The small-scale mills in this study were located "in or within walking distance of urban neighborhoods." The production was seasonal due to restrictions on sale of stored maize to any millers other than the four large industrial millers operating under the government's subsidized maize meal program.

There are two points in the study which are of interest with regard to the potential for maize milling in other countries or regions. One, coarse meal has more urban market potential than may be realized and, two, urban millers are taking advantage of a value-adding process that could possibly be carried out more efficiently by the small farmer.

In many areas maize meal is purchased in urban markets for sale in smaller rural markets. It is not uncommon for large sacks of meal to be purchased and re-packaged in smaller units for distribution and sale in rural markets. There are economic benefits to the society from the various handlings and transformations of the product as it moves from the field to the urban areas and back to the rural areas, but the final cost is usually higher than it would be if the maize could be efficiently grown, purchased stored and milled in the rural village or on the farm and delivered to the markets.

Much of the milling in rural areas is milling done for local residents for a fee. While this is a valid form of microenterprise, milling as a microenterprise is considered here to be a business in which the miller has linkages forward and backward in the production and marketing system.

Whether the possibility for milling at the village or farm level exists in any one locale must be carefully analyzed. A major constraint on this analysis is the lack of personnel capable of making the analysis.

The determination of the potential for maize milling as a micro-enterprise in an area and its development depends on a "package" of assistance being available to the potential entrepreneur.

Technology package. In the literature and in the field the term "technology package" is often used when someone is attempting to convey the idea that simply intervening with a piece of technology is not sufficient to achieve an economic goal; that the technology must be supplemented with activities to ensure that the potential benefits are realized from the technological intervention. There are other interventions necessary, not only in maize milling, but in any of the commodities which have small-scale industrial potential.

Maize milling and the marketing of the meal has potential in many areas. In most areas mills already exist and the economic potential may be in expanding the activities of the millers to include procurement of raw material, storage, and marketing.

Market analysis is the first step in determining if there is potential for a processed product. Market analysis is not a simple task and too often what is thought to be an analysis is little more than someone's opinion on market potential. In the socioeconomic world of the small farmer, there are very few qualified market analysts available for assistance.

Assuming that a market does exist, the development of a business plan is critical for even the smallest venture. This is very often not considered or is poorly handled, again due to lack someone qualified to provide the needed assistance.

The technology itself, be it milling, drying, packaging or other processing technology, must be accompanied by some amount of technical assistance to ensure that the process is carried out correctly and efficiently and that the technology is the most appropriate for the individual circumstance.

One other activity which may be necessary to include in a package would be that of organizational assistance if the users of the technology are a group or organization of farmers. Organizations may have to be established to produce, process and market a product, or an existing organization may have to be improved to be able to efficiently carry out these activities.

The question is, who should be responsible for implementing or coordinating these activities? In some areas projects are being implemented by international donor agencies and local nongovernmental organizations that are attempting to establish small farmer enterprises. Many projects have been completed that have had the same objectives. These projects have had varying degrees of success, but in very few rural areas has the ability to seek and out and develop potential microenterprises been developed.

The primary goal of agricultural research programs has been to increase agricultural production. Processing and postharvest handling of the increased product has received serious, but

sometimes inadequate, attention. The business potential of the product has not received much attention from research organizations. This is not considered to be a function of research and generally only occurs in a rural society when someone recognizes a potential for a business venture and a project is designed and implemented to develop the potential business.

A technology package should include the means to train the small farmer in the development and management of small enterprises either as individuals or as part of an organization. The extension of new technology to a farmer needs to be more than convincing the farmer to use the technology, he needs to know how to obtain the maximum benefit from it. The average small farmer does not have business skills, they must be developed. Market analyses that provide sufficient reliable information for making business decisions do not exist for most African markets.

Research organizations, at the national or regional level could provide this assistance as a logical extension of their research and extension programs.

Technical assistance for introducing new technology exists in nearly all research organizations. Some IARCs have well trained technology transfer specialists. Criteria should be developed to determine what level of technology transfer skills are needed in any given research organization. A review of the technology transfer capabilities of the various research organizations based on these criteria would establish the needs each organization has for improving their technology transfer capabilities.

Once these needs have been established for each organization, a program could be developed to provide training as needed. Some of this training, at a general level might be carried out at IARCs or at the regional level. Other training might require the presence of an outside technician, local or foreign, who works on locally specific training.

The development of business plans and marketing strategies and the introduction of management skills to a farmer or a farmers' organization would most likely require that someone in the research organization be trained in these skills or someone with these skills be added to the staff.

Assistance in this area is available from various sources. In addition to the nongovernmental organizations which work in rural areas in the countries in the region, there are various voluntary organizations that could provide long or short-term assistance to train local research staff members and help establish a program for micro-enterprise development.

Some of the long-term volunteers are available from the Peace Corps and similar organizations from other nations. These organizations normally can provide volunteers with specific skills if presented with a proposal that demonstrates the viability of the proposed project.

Short-term assistance for specific skill needs can be obtained from the International Executive Service Corps (IESC) or Voluntary Overseas Cooperative Assistance (VOCA). The volunteers

from these organizations are normally provided through an existing project, and may not be available in certain countries.

In all cases of the employment of volunteers, a local counterpart with appropriate education or experience should be assigned to work with the volunteer and carry on the activities after the volunteer finishes the assignment.

A review and analysis of the potential that exists in various countries and regions for technology development and transfer and the micro-enterprise opportunities that could derive from the technology may justify a project designed specifically to develop business development and management extension skills within the research organizations.

The Ministries of Agriculture in most countries have agricultural economists assigned to their staffs. Other agricultural economists are on the staffs of universities. These economists may or may not be involved in market analysis.

Market information is poor in most African nations, due in large part to the lack of a demand for the information and the informality of the market.

If a program can be developed within the research organization that extends the organizations' activities to agri-business development, local economists should be part of the program.

The ability to develop agri-business organizations and the skills to manage them probably does not exist in most countries. In some cases only additional training may be necessary for a person already in place. Some countries may have a project that is engaged in this development. If possible, an effort should be made to include someone from the research staff in an on-going organizational development project, if only for training, or implement a project specifically to develop these skills in a staff member(s).

A third party which should be included in any effort to create a micro-enterprise development capability is the local banks. If there are local "agrarian" banks they may already have an outreach program. In any case, the local banks are often an overlooked resource. Local credit organizations may also be able to assist in business and accounting skill development.

Involvement of the local banks or credit organizations may be especially beneficial if these institutions are to be future sources of financing for agri-business ventures.

2. Cassava:

Cassava is a staple in most of Southern Africa. Most of what is produced is used for human consumption but increasing amounts are being used for livestock feeds and industrial uses.

Fresh cassava has a very short shelf-life (about two days, depending on variety) and therefore has little potential for storage and market speculation. The F.A.O. technical compendium,

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previously cited, offers suggestions on storage techniques but there would seem to be very little potential for a business based on storage.

One method of shelf-life extension mentioned as only "research findings" is that of surface waxing cassava. This method is used on cassava imported to the U.S. from Costa Rica under the brand name "Melissa" mainly for the ethnic market. The cassava is not peeled and is completely covered with a paraffin coating from a dip in melted paraffin.

This product may have potential in the ethnic markets of Europe where other ethnic foods have been successful.

Cassava production methods are poor and production is often in areas of depleted soil as a final crop at the end of a rotation. Insect and disease management are poor (16). If research organizations can assist in improving production or if production is currently greater than fresh market demand, the opportunity may exist to produce flour for local dishes or brews. Livestock feed supplements can also be from cassava employing the same technology needed to prepare the cassava for grinding into flour.

The F.A.O. technical compendium cited (18, above) has a very good review of the processes, costs and uses of cassava flour. The processing costs, both fixed and variable, for a processing plant with a capacity of 2 tons per hour are presented. There is no information on price or profitability of the plant.

Processing cassava into flour is technically demanding, especially since it is the production of a product for human consumption which has high visual and organoleptic standards.

Probably the factor most critical to the profitability of cassava flour production is the assurance of a reliable supply of cassava at a set price in order to maintain the efficiency of the processing operation.

Peeling chipping and drying cassava for use as an animal feed supplement may have potential in some areas. Cassava has a high carbohydrate content and can be mixed with other feeds to where it is about 10 percent of the feed.

In those areas where bananas and plantains are grown, the same processes used for production of supplement from cassava may be used for bananas and plantains. These processes are capital intensive to the extent that they would most likely require a farmers' organization to provide the capital and management of the operation.

What is very important in the cost structure of this processing is the price paid for the raw material. Bananas and plantains used for processing are usually those fruits which have no fresh market value and are therefore obtained at very low cost by the processor. If growers are the processors, as is considered in suggestions in this paper, improved or increased production among a number of growers may make this a feasible project.

Either singly, or in combination, cassava, bananas and plantain may provide the raw material for a successful feed supplement business.

3. Food legumes

Legumes and pulses consumed in Southern Africa comprise a diverse number of seed crops. The most common of these are the cowpea, pigeon pea, soybeans, groundnuts, faba beans, lentils, broad beans, kidney and other *Phaseolus vulgaris* varieties.

Legumes present some limited opportunities for microenterprise development. These opportunities include the purchase, processing and storage of legumes for sale, dried and whole, milled or roasted for local consumption. Some of intermediate processing steps may, singly or in combination, offer business opportunities.

Threshing. Most of the pulses are harvested by removal of the entire plant from the ground. The plants are then hung to dry and once the pods are dried they are threshed to remove the seeds from the pods. Threshing is accomplished by use of a stationary machine or by hand-threshing. Unprocessed crops are the least expensive to purchase. Threshing may be the first step in processing legumes for market or, in some areas, may be a profitable service in itself.

Drying. The drying of most legumes to a desired degree of moisture is not as difficult as maize or some other grains. There are technologies for drying legumes, but these are generally employed with products such as kidney beans commercially grown for large urban markets or export.

Hulling. Some legumes, such as cowpeas and pigeon peas, require hulling. An enterprise that would be established for production and/or purchase of legumes requiring hulling would need to purchase a milling machine for that purpose.

Many milling machines can be used to mill or hull different legumes or grains. In many cases the microenterprise may be built around a major investment such as a mill for grinding corn. Alternate uses for the mill should be investigated to optimize the use of the mill.

Storage. Legumes are seasonal and as such normally have a high demand during certain months of the year. Losses in storage due to insects and undesirable physical changes are a serious problem in legumes. In planning a business venture, it would be prudent to consider marketing a volume of legumes that would make a modern storage tank and insect control feasible.

Milling. In some regions the cowpea is milled into a flour. This may be a viable enterprise on its own or part of a "mixed" operation in which some cowpeas are marketed whole and others milled. Milling cowpeas might be a means of diversification if a mill already exists for another product.

Roasting. Chick-peas and cowpeas are commonly roasted and eaten as a snack. The peas are usually roasted in their husk. Roasting cowpeas and chick-peas for sale in urban markets may be a business opportunity in some areas.

Packaging. All processed products need packaging of some kind. The packaging may be to facilitate handling or provide units of a convenient size to consumers. It may also be to preserve the quality. With the use of graphics and other features such as resealability or reuse, the package may improve the marketability of the product.

In nearly all markets there is a premium for a unit of product, such as a kilogram of corn meal, that is prepackaged as opposed to a kilogram purchased from a bulk container such as a sack. The premium is normally greater than the cost of the sack of meal and the packaging materials, providing a return to the labor of packaging and distribution.

Repackaging is often carried out in urban areas by people who purchase bulk containers of grains or legumes and plastic bags of various sizes, depending on market requirements. This repackaging could be a prepackaging in the rural areas where the products are grown. There is very little required in terms of equipment, a simple scale, plastic bags and a sealer or ties and some tool or simple machine for filling the bags.

What may be more difficult, and where the entrepreneur may need some assistance is in market development or penetration. The cost should be less to pre-package in the rural areas, which would provide an advantage. Some effective marketing may develop some specific needs of retailers that can be exploited.

Legumes, grains, and meals are used in combinations in the diets of many Africans. It may be feasible for some markets to prepackage locally preferred combinations of ingredients in meal-size packages as a convenience to consumers. The products used may produced by a small farmer, his neighbors, or a combination of purchased and locally produced products.

Government policies

A number of microenterprises have potential for success in any of the Southern African nations, but the ability to realize this potential is often constrained by government policies which control the purchase and sale of commodities through marketing boards and which subsidize prices.

As an example, the study by Jayne and Rubey (17), on maize milling in Zimbabwe indicates that government policy of subsidizing commercial maize milling operations and controlling the sale of grain stocks has various adverse effects on the economy, including the constraining the development of small milling operations which could not only provide income to the millers, but also provide supply the demand for meal at a lower cost.

Any proposed microenterprise must take into consideration the government restrictions that

apply to the enterprise whether it be control of raw materials, control of market access, import duties on equipment and supplies needed for the enterprise, lack of access to foreign currency or any other restrictions or controls which may which limit the success of an enterprise.

Processing equipment

There are various microenterprise opportunities which can be developed in southern Africa. Each country has its own uniqueness in consumption and some consumption patterns are similar throughout the region.

The number of failed projects and businesses and abandoned equipment in the region are testimony to the lack of an ability for many to analyze those factors which affect the viability of a small business. It is also often a reminder that the appropriateness, quality and maintainability of equipment around which the business was developed was lacking.

Processing equipment is manufactured in several southern African nations and many types, especially mills, are imported from regional manufacturers or suppliers as well as extra-regional (usually European) suppliers.

A grain from one region may not have the same milling characteristics as the same grain from another region, a milled product from one type of mill may be acceptable to consumers in one region and not in another. Equipment selection is not a straight-forward process.

During the planning phase of a microenterprise local or regional research organizations should be consulted to determine what information exists about equipment suited to the local conditions.

If local information is not available, it should be possible for the NARC or RARC to consult with the various IARCs or consult their publications.

As was discussed earlier, most research institutions have knowledge of "appropriate" technology for the crops with which they work. To foster or assist local private enterprise someone in each institution should have a knowledge of the economics of the application of the equipment in order to assist potential entrepreneurs in the choice of equipment and its efficient operation.

A source of information cited earlier, *Postharvest and processing technologies of African staple foods: a technical compendium,* published by F.A.O. is a very useful source of information on staple commodities, their production, processing and consumption. There are some aspects of the compendium which could be improved or enlarged. Some suggestions are offered here with respect to those who assembled this information.

1. Several types of equipment and processes (e.g., "Brook" dryer, "FAO" and "Grant" huskers, and the French "SEPIAL" process) are mentioned, usually with some

explanation of the process, but with no further reference as to where more information might be obtained about the equipment or process.

2. A review of existing equipment and its suitability based on experiences in different areas would be helpful to avoid the purchase of equipment that is inappropriate, difficult to maintain or for which spare parts may not be readily available.

3. It would be very helpful to have names and addresses of manufacturers of processing equipment or their representatives. Addresses and contact persons at national or international organizations where specialized processing equipment has been developed.

4. Critical to the decision to purchase a piece of equipment is the F.O.B. cost, the manufacturer or supplier. Other costs such as transportation and import duties, when required, can be determined by the buyer, but it would be helpful to know what the purchase price of the equipment is, allowing that this may change.

5. All equipment has certain technical specifications that need to be known by the potential buyer, among the most important are the production rate of the equipment and the energy requirements.

Some of these suggestions may be answered in other FAO bulletins on specific topics that are listed on the back of the publication.

It may be unfair to expect that all of the above information would be in a single volume. However, for successful processing micro-enterprise development, this information must be made available to potential entrepreneurs.

This information should be part of the "technology package" recommended earlier in this paper. While much technical information about available equipment can be found in various sources, it may be worthwhile for research organizations to test a variety of mills or other equipment to determine which are the most appropriate for local needs.

The effectiveness of local and regional research institutions in ensuring that agricultural enterprises can be developed and sustained can be greatly improved if the ability to assist in the development of micro-enterprises is built in to the organizational structure. This assistance should go beyond providing only technical assistance in production and processing and ensure that it is available continuously on all aspects of business development, management and marketing.

Notes

1. Bourne, M.C., 1977. *Postharvest Food Losses—the Neglected Dimension in Increasing the World Food Supply.* Dept. of Food Science, Cornell University, Ithaca, N.Y. p. 3.

2. Greeley, M., 1987. *Postharvest Losses, Technology, and Employment: The Case of Rice in Bangladesh.* Westview Press, Inc., Boulder, Colorado. p.10

3. Greeley, M. (Op. cit., p. 15).

4. Miracle, M.P., 1966. *Maize in Tropical Africa.* University of Wisconsin Press, Madison, Wisconsin. p. 242.

5. Schemerhorn, R., Maloney, R.P., and Grierson, W. 1991, "Economic Considerations in Reducing Postharvest Losses in Developing Countries." *Proceedings of the Interamerican Society for Tropical Horticulture*, Vol. 35.

6. Personal conversation.

7. National Academy of Sciences, 1978, *Postharvest Food Losses in Developing Countries.* National Academy of Sciences, Washington, D.C.

8. Personal conversation.

9. Greeley, M. (op. cit., pp. 33-39).

10. Bourne, M.C. cited in Greeley (op. cit., p. 10).

11. Greeley, M. (op. cit., p. 26).

12. Lionberger, H.F. and Gwin, P.H., 1991. *Technology Transfer, From Researchers to Users.* University of Missouri, University Extension. p. 1.

13. Madu, C.N., 1989. "Transferring Technology to Developing Countries—Critical Factors for Success," *Long Range Planning*, Vol. 22, page 115.

14. Bencini, M.C. and Walston, J. P., 1991. *Postharvest and processing technologies of African staple foods: a technical compendium,* F.A.O., Rome, p. 29.

15. Jayne, T.S. and Rubey, L., 1993. "Maize Milling, Market Reform and Urban Food Security: The Case of Zimbabwe," *World Development*, Vol. 21, No. 6, pp. 975-88.

16. Op. cit., FAO, p. 177.

17. Op. cit., Jayne and Rubey.

Input marketing position paper

by

Tom Zalla

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Executive summary

Other things being favorable, successful technology transfer is most likely to occur where there are effective links between commodity markets, input supplies, extension and credit. As agriculture in a country develops, private agribusiness firms play a greater role in developing these linkages. However, it will be a long time before this market system becomes important to resource poor farmers and smallholders in most African countries. For them, public marketing organizations, the formal private sector and informal markets will continue to serve most of their needs for the foreseeable future.

One of the priority issues for research over the next ten years is the level of development of input markets expected to prevail when technologies being developed today are ready for diffusion to farmers. More developed marketing systems increase the range of high input technologies researchers can offer to farmers with good prospects for adoption. Unless donors make developing market linkages an integral goal of project design and implementation, the transfer of economically promising technologies will continue to suffer.

An ideal input marketing system will involve a combination a several types of marketing channels. How each channel responds to new technologies depends on several factors. These include the level of development of the agricultural sector, the characteristics of the innovation, the macro policy environment, the regulatory and legal framework, the nature of illicit enrichment that affects the various marketing channels, and the private opportunity cost of capital. The way in which subsidies on agricultural inputs have been applied in SSA has often made it difficult for nonpublic marketing systems to play an effective role in input distribution.

In spite of its importance for facilitating technology transfer, credit programs have a sorry history in most of Africa. Lax program discipline and failure to provide adequate extension support in the use of the technology financed by the credit are the principal reasons for this failure. Approaches to lending that are based on rigid discipline, village groups, village credit unions or affinity groups offer possible solutions to this problem, and deserve study by the NARS.

Ineffective agricultural extension in many sub-Saharan countries limits the speed with which improved technologies spread. Severe public sector budgetary problems and poor public sector discipline do not offer much hope that this problem will change. But the confluence of the emergence of nongovernmental organizations as an important organizing and motivating force for rural development, coupled with the recent devaluation of the FCFA, present the first real opportunity since independence to develop farmer financed and farmer controlled extension services in many countries.

Vertically integrated production and marketing operations have proved effective in transferring utilizing technology for some cash crops. They work best where there is good manage-

ment. In the case of cotton, there was a spillover positive effect on the diffusion improved technologies for cereals. Such approaches work best with commodities that have limited alternative marketing outlets for farmers.

A wide range of public sector organizations and projects provide inputs and transfer technology. Unfortunately, those concerned with agricultural inputs are frequently monopolies that perform poorly. Breaking these monopolies via policy reform is probably the most effective way of improving the performance of input markets. Considerable progress has already been made in doing this.

Cooperatives, and increasingly, farmer associations, are important marketing intermediaries throughout Africa, especially in the anglophone countries. In the francophone countries they are less dynamic and less independent of government control. In the future more attention should be given to forming and empowering smaller groups of farmers based on affinity or economic cooperation to provide inputs and credit to members.

The formal private sector tends to be oriented toward larger commercial farms in most countries. This type of marketing system is, again, most developed in the anglophone countries and in those countries with a commercial farming class at independence. As farmer groups develop the demand for inputs we can expect the formal private sector to become more active in providing support services to them.

Nongovernmental organizations are becoming active in input delivery directed at smallholders and resource poor farmers. They offer promise for breaking bottlenecks associated availability of extension and credit for these farmers.

Informal markets are by far the most responsive to the needs of small farmers, but perform best when the formal private sector is dynamic and healthy, and public sector intermediaries are supportive. Development projects need to develop linkages between these two systems in order to improve the flow of information, inputs and technologies for smallholders.

To increase the efficiency of input markets for transferring improved technologies to farmers donors and governments should pay more attention to developing market linkages in project design and implementation; stop regulating marketing margins for agricultural inputs or ensure they are sufficient to allow delivery to remote rural areas; take measures to reduce illicit enrichment directed at private sector marketing intermediaries; and help national agricultural research systems to develop an effective outreach capability.

Priority issues for research on input markets include the impact of specific government policies and regulations on input markets and technology transfer and small group approaches for delivering agricultural credit and inputs to small farmers.

Input marketing position paper

1. Importance of markets

In a recent ARTS review of adoption of research results in Africa, Christensen (7) concludes that success is most likely where there is a supportive market for the commodity, and where there are effective links between commodity markets, input supplies and credit. The report notes that poorly functioning markets and unreliable input systems led uniformly to failure.

Underdeveloped input markets and the lack of availability of key agricultural inputs in a timely fashion are limiting agricultural output in many African countries. Time and again, experience has shown that when output increasing technology is available, the physical environment is favorable, inputs are provided on time, and prices are right, farmers respond with sharp increases in output.

With sustainable development the focus for change moves from projects to the human and institutional relations changed or needing to be changed by those projects (27). It no longer is sufficient to assure that a project will be able to procure the inputs needed to attain its physical output goals; more attention must be given to how those inputs will be provided after project completion. In most cases this means greater attention to *developing* private sector input markets as part of project implementation. Where resource poor small farmers are the focus, it will often require continuing public sector support while improving informal marketing systems and developing associations of farmers that can assume some marketing functions themselves.

The growth of cash markets for output is just as critical to the success of research breakthroughs as the availability of supportive input markets. The ARTS report noted that successful cases of adoption of new technologies in the absence of cash markets are rare unless there is a severe threat to household food security (7). Cash markets identify which goods have sufficient effective demand to justify investments in technologies to produce them. They provide farmers with the wherewithal to invest in the cash inputs needed to make the new technology profitable.

There is no single way to develop supportive marketing systems, though certain approaches seem to have greater success under particular circumstances and for specific crops and inputs. Effective and resilient input markets are characterized by a mix of delivery systems, each which responds to opportunities for innovation in its own way. In general, the range of effective choices increases as a country's agriculture develops.

2. Factors affecting how input delivery systems respond to technical innovation

2.A. Level of development of the agricultural sector

As the agricultural economy of a country develops, private agribusiness firms tend to assume a greater role in supplying information and inputs to farmers. In so doing they expand the range of options open to researchers for developing and adapting promising technologies. Private agribusiness firms already play a major role in developing and diffusing new technologies in Zimbabwe, Kenya, Zambia, Cameroon and the Ivory Coast. These are countries where large scale commercial farming existed at the time of independence.

Private agribusiness is much less important in the Sahelian countries and in the poorer countries of East and Central Africa, where relatively few large commercial farms exist. Some of these countries have significant private enterprises engaged in producing and marketing specialty crops for export or processing. In general, however, government programs and donor projects continue to generate most new technology. This will probably continue to be the case for the foreseeable future. Weak input markets will continue to be a factor to weigh in designing technology development programs for such countries.

One of the priority issues for research over the next ten years is what kind of input delivery systems will be available and developed when the technology reaches the diffusion stage. To the extent that weak input markets will be the norm, then more farmer-controlled technologies such as composite seed varieties, biological pest resistance, stall-feeding of cross-bred dairy cattle and composting are indicated, since these are easily transmitted through informal market channels. To the extent more developed input and output markets will be available, researchers can focus on more input intensive technologies such as hybrid seed, fertilizer and agricultural chemicals, that may offer higher output increasing potential.

Even in countries with a more developed agricultural sector, private agribusiness gives relatively less attention to resource poor farmers, necessitating a continuing role for the public sector in this area. In order for the private sector to play a more dynamic role in promoting technical progress among such farmers, donors will have to make market development a specific goal of development projects and programs aimed at them.

2.B. Characteristics of the innovation

The linkages that are formed within and between the various marketing channels as agriculture develops are conditioned by the characteristics of each innovation. The farmer's familiarity with an input, how divisible or complex it is, the farmer's ability to discern the quality or purity of the input, and how affordable it is all suggest which marketing channel is likely to be most effective for stimulating its adoption. In general, more familiar, simpler and affordable a technologies and inputs can be distributed through informal markets, providing farmers with better accessibility and promoting wider transfer and adoption. More complex

technologies may require greater levels of support or regulation than are likely to be forthcoming from the informal system alone. Otherwise adulteration, lack of knowledge with respect to effective use, or lack of credit may prevent farmers from realizing the full potential of the technology.

2.C. Macro policy environment

The macro policy environment is, arguably, the single most important factor with respect to how effectively input markets facilitate the transfer of technology. What is not always appreciated is that many of these policies affect the various marketing channels differently. Allocation of foreign exchange, export licensing, transportation and marketing taxes and fees, and input subsidies are often administered in a way that favors parastatal and government channels over the formal private system. The informal system, on the other hand, may have little difficulty competing is such situations, This was the case in Niger in the mid-80s when merchants smuggled highly subsidized fertilizer from Nigeria into Niger via informal market channels, in spite of a monopoly on inputs held by the input marketing parastatal.

Without a doubt, policy reform has been the most important "new technology" affecting input markets over the past ten years. In countries where reforms have been completed, agricultural markets have become much more resilient. They have continued to provide market clearing supplies of food staples and critical inputs in the face of severe public sector budget problems. Reforms aimed at freeing prices, movement of agricultural commodities both within and between countries, breaking the monopolies held by many parastatals engaged in producing and marketing key agricultural inputs, eliminating subsidies and pan-territorial pricing go a long way toward explaining why record public sector budget deficits have not resulted in the gut-wrenching shortages that have periodically crippled the economies of SSA countries in less severe times. The reforms have decoupled economic performance from public sector growth to a remarkable degree.

Fiscal reforms imposed by donors on nonagricultural sectors have had other highly desirable effects from the point of view of technology transfer in the agricultural sector. For the first time ever in many countries, especially the francophone countries, college educated men and women are open to employment in the agricultural sector as public employment guarantees for graduates fall by the wayside. Thousands of technicians trained and discarded by projects are now open to employment at wage levels that are within the reach of farmer associations. Pulling these two groups together via nongovernmental organizations provides the first real opportunity for establishing farmer financed and farmer controlled extension and input supply systems in such countries since independence.[1]

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[1]The recent devaluation of the FCFA was a major step in this direction. If governments can resist the urge to insulate urban wage earners from the effects of the devaluation by holding food crop prices artificially low, there is considerable potential for expanding production of rice, maize and sorghum in the FCFA countries using improved technologies.

Allocation of foreign exchange for imported inputs is a continuing problem for most marketing systems. The poultry industry in Kenya, Tanzania, Senegal and other countries, for example, goes through periodic flock liquidations because of the inability to obtain hard currency for feed, mineral supplements or veterinary supplies at certain times. In some countries orders of fertilizer and other inputs are delayed for the same reason. One of the reasons for the success of the West Africa cotton parastatals, on the other hand, is their first call on cotton export earnings for obtaining imported inputs essential to the technical package.

2.D. Regulatory and legal framework

In the francophone countries commercial policy often favors a few traders or businesses. Some of these are private sector firms, but with an effective monopoly or oligopoly on the market for a particular input. Another mechanism for favoring selected large merchants includes setting the fee for import licenses so high that only the largest traders can afford to pay them. Both practices are anticompetitive and probably not much more beneficial for consumers than an inefficient parastatal.

Such favoritism frequently impairs market performance by subjecting input supply to the management skills and market power of a few individuals rather than to the forces of competition. The disruptions in supply which inevitably result add to risk, reduce the use of inputs by farmers and increase costs to consumers.

Competition and the availability of market information are important determinants of market efficiency and effectiveness. While most of us would probably agree that involving the private sector usually leads to effective competition, we should not overlook the fact that this is not always the case. The real challenge is to minimize interference with the operation of markets, while supporting their development as much, and as rapidly, as possible.

The way in which governments allow public services and parastatals to handle revenue from product sales also has an impact on availability of inputs. In many countries governments require that revenue from product sales go to the treasury, not into an operating account of the service or partastatal. This subjects the availability of funds for ordering inputs to the political and budgetary process of government. In effect, the parastatal is not able to generate operating capital from its own sales, except, perhaps with an 18 month delay, and then only if the budget allocation is adequate. So, unless everything goes according to plan, including the weather, shortages should not be surprising.

What all of these legal and regulatory dimensions have in common is their focus on issues other than timely availability. What they fail to recognize is that an input that is not available helps no one, no matter how cheap it is or how high its quality.

2.E. Illicit enrichment

Illicit enrichment adds substantially to private and informal marketing system costs and discourages competition in transport in those countries that allow frequent road checks. In Niger, for example, roadblocks by police, highway patrol and customs officers occur, on average, once every 50 kilometers, with an average bribe of $10. These informal road taxes are not usually assessed on government, parastatal or donor project vehicles. Moreover, large vehicles pay more than smaller vehicles, but not proportionately more, so they enjoy a significant cost advantage (28). Besides adding to the cost of inputs supplied by the private sector relative to the public sector, the bribes tend to restrict competition from the more widely available and fiercely competitive smaller traders. Technicians in contact with farmers are also in a position to extract payment for services that are, in theory, free.

The regularity of bribes paid at road check points in some countries suggests that such activities occur with the full knowledge and acquiescence of political leaders. Policy reforms limiting restrictions on the movement of goods within national boundaries would, no doubt, reduce the number and amount of bribes and lower input marketing costs.

Bribes in the delivery of agricultural inputs may be another matter. Giving farmers control over employment and compensation for whoever provides these services, or empowering farmers to provide these services themselves should provide some relief.

3. Other issues that affect performance of input marketing systems in Africa

For viable technical innovations to spread rapidly, input markets must be efficient, timely, flexible, reliable and resilient. In the sub-Saharan countries where agriculture is less developed, climatic variability combines with a high private sector opportunity cost of capital to make it unlikely that private market intermediaries alone can provide this type of market environment. In many cases there will be a continuing need for a public entity to finance or hold buffer stocks for critical inputs.

Climatic variability. What applies to rainfed rice as shown by Tinsley (25) applies to agriculture in general. As he points out, there is no normal rainfall or weather pattern, only averages. The onset of the rains has at least a six week range and monthly rainfall can vary by over 50 percent on the average. Farmers recognize this and utilize cropping and land management systems that respond to this variability. A merchant may project a likely demand for fertilizer based on an average weather pattern, only to see half of it unsold at the end of the season; or intermittent rains may require a second, or even a third planting.

Faced with such variability few merchants are willing to carry enough inventory to cover the more extreme situations. Unless some other market participant carries a high level of inventory, there will be a tendency toward shortages of essential inputs in better than average years. With long supply lines those countries without a domestic input industry may have little hope of obtaining additional supplies once the weather outlook is defined. And if farmers are forced to replant, they may have to use food stocks for seed. If the stocks consist entirely of hybrid grain, the results could be bleak indeed. The critical question for each commodity is how often these situations are likely to arise, and what will be the strategy to deal with them if they occur frequently enough to warrant action.

Inventory management. Adequate inventory is a major problem at all levels in Africa, from the smallest merchant to the largest parastatal. There is a pronounced tendency to wait to reorder until stocks are depleted or a sale is in hand. Few market participants seem to want to carry inventory, either of materials or cash.

The desire to minimize inventories is not surprising if one concedes that the cost of capital in informal credit markets may approach 60–100 percent at certain times of the year. Not surprisingly, such high rates occur just as farmers have the greatest need for timely supply of inputs. The weather variability accentuates the magnitude of the inventory problem.

Public or para-public entities do not face the same pressure to keep working capital moving, but they do have to answer for carrying excess inventory. Therefore, unless analysis and planning leads to an explicit decision to carry excess inventory levels for certain critical inputs, the justification may be forgotten and inventories drawn down just as they are most needed.

Inventory management responds to training if there is a political will and ample capital to

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undertake the necessary purchases sufficiently in advance of the need to allow timely delivery. The Togo Animal Traction Promotion Project did not manage to solve this problem, primarily because project management did not accept that it, rather than the projects that ordered spare parts from it, had responsibility for anticipating demand or acting as a supply of last resort (30). Rwanda's Support to the National Inputs Program (APNI) had the same attitude toward fertilizer and agricultural chemicals, even though it had a monopoly on imports (16).

To function in such environments, projects need an independent inventory management program, while they work on reforming the role of the principal input supply agency. This latter point is critical, for once a project is completed, it is no longer a reliable and timely source of critical inputs. This is an important reason to have development projects include as an explicit goal the development of effective input market linkages.

Even when an institution accepts responsibility for anticipating demand, cumbersome procedures for acquiring materials or supplies can make it difficult to perform effectively. Obstacles include inflexible disbursement procedures by donors and host country institutions that support development projects, and long supply lines that stretch abroad. Exchange controls add to the problem, as do gifts of inputs that the donor requires be distributed free or at a subsidized price to farmers.

Clearly, a dynamic, competitive private sector may be better suited to perform this function. But what do we do while we are waiting for this to evolve? High transactions costs associated with expedited movement and illicit enrichment may give the appearance of monopoly profits where none exist. It's also difficult to detect over-invoicing and other mechanisms for exporting capital where exchange controls are in effect. Such problems make it difficult to convince many national governments that greater freedom for the private sector will lead to anything positive.

Market development. Economists tend to assume that an input will spread on its own if it is profitable. This may be true if time is not an issue. Unfortunately, there is a lot of friction that unnecessarily prolongs the process. In many cases taking specific measures to increase the availability of inputs can accelerate the rate of adoption.

Developing demand for inputs is partly the function of extension. But if there is genuine desire to involve the private marketing system, projects will have to go further than that. Initially, demand needs to be concentrated so that the market potential is enticing to merchants and distribution costs are kept to a minimum. Pricing policy for inputs within the project must be based on actual costs for the input plus a reasonable margin, so that merchants operating in an unregulated market would find the trade profitable. This flies in the face of the goals of many donors and most African governments who want to "help" farmers, but it works. The Togo Animal Traction Promotion Project (PROPTA) in the late 1980s used this approach successfully to stimulate the private sector to supply traction animals directly to farmers. PROPTA charged about 40 percent more than the private sector for a pair of oxen (30).

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Other approaches for developing demand for inputs include providing credit to merchants or farmer associations to cover inventory; end-of-season repurchases of unsold inventory to free-up storage space and working capital for other items; assisting farmer associations establish themselves as marketing intermediaries financed from the sale of inputs to members; and making smaller and more affordable packaging for inputs available to farmers.* As markets develop input suppliers assume a growing role in providing product information in-country. In general, the absence of manufacturers representatives in many countries is partly a result of insufficient sales to justify such a position. Zimbabwe, for example, is well served by manufacturers reps. In much of the rest of SSA, they are available on a regional basis at best. Thus market development *for* the private sector will usually be a precursor to market development *by* the private sector.

Subsidies. Subsidies, direct or indirect, effectively exclude the private sector and other nonsubsidized intermediaries from participating in input markets unless they are applied in a way that applies to all market participants equally. This is not usually the case in SSA. Subsidies usually favor public sector market channels in their application.

Regulated marketing margins that do not cover costs are a common form of indirect subsidy that causes problems for input markets throughout SSA. Too often, regulatory entities focus on what farmers or consumers can afford instead of on the cost of providing the service. This leads to shortages, especially in rural and more distant urban markets, as the private sector withdraws from marketing the inputs. With respect to fertilizer, marketing margins set in this way are rarely adequate to finance more than intercity transportation costs.

When regulated marketing margins are set too low development projects or government services must absorb some of the distribution costs in order to make inputs available to farmers in rural areas. Politicians and planners need to focus on input availability and not just on the cost of inputs. Cheap inputs that are not available help no one.

It is too simplistic to push for the elimination of all subsidies in agricultural markets. To do so discredits donors in the eyes of policy makers who have more than the livelihood of agricultural producers on their mind. Subsidies may even be required to avoid an inefficient allocation of resources induced by incomes and other policies. Donors would probably be more effective if they focused on showing governments how to apply their subsidies so as to minimize the undesirable effects of the subsidies on market performance, and let fiscal pressures determine the amount of subsidy. Giving the NARS a capability to conduct policy analyses in a regional context would give such studies more creditability in the eyes of policy makers and create an articulate national force with a vested interest in how subsidies are administered.

Agricultural credit. Availability of credit is critical for rapid adoption of many new technologies when the economic attractiveness of the technology is not sufficient to overcome the high private opportunity cost of capital. Indeed, many of the technology transfer success stories in SSA are based on effective and disciplined agricultural credit programs. This is true for hybrid maize in Zimbabwe (13), cotton in francophone Africa, and coffee coops in East

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Africa. All of these operations would certainly be less successful if they had to rely on farmers paying cash for pesticides, fertilizer and other inputs.

By substituting borrowed funds for a farmer's own capital, credit brings the private opportunity cost of inputs closer to their social opportunity cost, and thereby stimulates demand. Moreover, offering seasonal credit strengthens the hand of extension by eliminating any excuse for not following recommended production practices.

Assuring repayment of credit in a less structured environment has proven very difficult in SSA. In many credit programs started over the past 15 years, poor administrative discipline has lead to a pattern of sharply declining repayment rates during the first three years of the program. Eventually the programs are terminated, rupturing the supply of inputs. Senegal, for example, has wiped out the credit arrears of its peanut farmers at least twice since independence. Problems with credit have been so bad that in recent years USAID missions in Africa have refused to consider support for agricultural credit under any circumstances.

The problems with agricultural credit need to be solved or small farmers will continue to use improved inputs well under socially desirable levels. They can be because credit programs are not failures everywhere.

A credit program for fertilizer studied by the author in Malawi in the mid-80s, and one for animal traction in Northern Togo reviewed in 1988 were notable for their financial viability. The common element to the successful programs was good extension support with respect to proper use of the technology, and ruthless discipline with respect to repayment. No compassion. Relief had to come from elsewhere or farmers lost their equipment and their down payment.

When farmers know they have to repay credit they carefully evaluate the economics of a technology before accepting it. They'll take it because they believe it will make them money, not because it won't have to be repaid. If the credit program is integrated with extension as it should be, the farmer will learn how to use his equipment correctly, and will succeed in generating the income needed to repay the credit, in most instances. With this kind of discipline and support, credit will be available the next year, and every year thereafter.

In many countries of Africa nongovernmental organizations are working with credit unions and farmer groups to establish affinity based credit associations for mobilizing local savings and maintaining greater social control over credit programs. The affinity group approach has proven effective when coupled with good financial controls and reporting to members.

Agricultural extension. Matlon et al. (14) has noted with respect to rice that, almost without exception, national extension programs are virtually moribund. My own experience with respect to agricultural extension in general in SSA would lead me to the same conclusion. Inadequate training and supervision, limited resources for travel, and failure to adapt extension programs to known public sector resource limitations are some of the principal reasons.

Public sector budgetary processes make the input supply function of many MOA extension services very unreliable. And resource constraints make follow-up tenuous at best. In such a context it's hard to see how any but very simple and very dramatic technological improvements can get very far, very fast.

One way to improve extension services on a sustainable basis in SSA, when many government budgets are depleted and extension services are poorly disciplined, is to make extension agents accountable directly to the farmers they are supposed to serve. Over the years the author has observed a number of attempts to do this, some rather successful. Section V of this paper describes what is being done in the Senegal Southern Zone Water Management Project with this approach. Without an effective extension program TDT can hardly realize its full potential.

4. Important input marketing systems in Africa and how they affect technical innovation and progress

4.A. Vertically integrated production and marketing operations

Some of Africa's major success stories from the perspective of research and the adoption of improved varieties and production technologies come from integrated production and marketing parastatals concentrating on a cash crop. Two well known examples are cotton in francophone West Africa and tea in Kenya.

The Compagnie Francaise pour le Developpement des Fibres Textiles (CFDT) and the national successor programs managed by it have succeeded in sharply increasing cotton production in West Africa. The organization in Mali (CMDT) obtains the highest yield for rainfed cotton in the world.

Under the CFDT approach, income from cotton provides an economic incentive for the adoption of animal traction as well as improved varieties and production technologies for maize and sorghum. CFDT carries out its own research, manages its own extension service, provides inputs and credit, and assures conformity to a precise-crop rotation and crop management system. timely inputs supply, credit, disciplined extension services, marketing support and supportive prices for output, all combine to produce an attractive technical package. According to a recent study, by 1990 some 96 percent of CFDT cotton area was receiving four insecticide applications each season, 98 percent received fertilizer, and animal traction is practiced by 80 percent of the cotton growers (7).

CFDT demonstrates the ability of self-contained systems to expand area and continue to improve technology in spite of an overvalued exchange rate that, until recently, produced high costs of production on world markets. The marketing organization supported farm prices by selling to local mills at a higher price than the price received in world markets, in effect partially compensating farmers for the negative effect of the exchange rate. To enable private markets to do this governments would have to establish export subsidies and manage the fiscal problems this would create. The recent devaluation of the CFA has solved the problem of an overvalued exchange rate and should provide a new stimulus for successful parastatals of this type in the CFA zone.

The scale of the operations of the larger and more successful vertically integrated parastatals provides a demand driven link with research, and tends to make the organizations heard among policy makers. In the case of CFDT, this has resulted in a more favorable macro policy environment, though the fact that cotton is an important source of foreign exchange in most francophone countries may have a lot to do with this.

The high level of control in integrated operations like CFDT provides an ideal testing ground for research recommendations, and makes extension and credit discipline easier to maintain. Because of the central focus on a cash crop and control over so many aspects of production,

management can intimidate farmers into adopting certain inputs (multiple sprays of pesticides, in particular) when the economics are not apparent to farmers, but are beneficial for product quality.

The major strengths of the vertically integrated marketing and production organizations are their assumption of responsibility for everything, and their participation in the profits of the enterprise. the project alone is responsible if inputs are late or insufficient. Little is left to chance. Their demand for inputs is often substantial enough for governments to allow them to purchase inputs directly from abroad or from in-country manufacturers rather from monopolistic intermediaries, thereby increasing the likelihood of their timely availability. Finally, with cash crops like cotton and tea, informal markets provide little competition for output. This greatly reduces the ability of farmers to avoid repaying input credit.

The major strength of this type of organization is also its major weakness: results depend on the effectiveness of project management in important measure. With cotton in francophone Africa, it has generally been good; but nothing says it has to be. Indeed, CFDT management is sometimes accused of being autocratic and inattentive to farmer complaints regarding the fit of the operation with the farming system, or concerns about certain aspects of the technical package.

Mali's Office Du Niger, a large rice irrigation system, provides an example of another hierarchically structured parastatal with a more checkered history. It also demonstrates the dramatic effect that suitable sectoral reform can have on input markets and the performance of such institutions.

Improved irrigated rice varieties have been available in West Africa for many years. Large scale rice production dates to before independence. Production techniques are relatively well developed, and extension has generally been available, if not always effective. Most inputs have also been available, although not always at the right time or on credit. Usually the perimeters are structured as cooperatives, with a central authority responsible for central water management and pump operation, and cooperatives responsible for land preparation, production and tertiary water distribution.

Prior to the emphasis on sectoral reform it was common for irrigated rice yields to range between 2.0 and 3.5 tons per hectare per crop cycle. The low yields relative to potential are variously attributed to poor land preparation, ineffective extension support, poor quality seed, untimely planting, heterogeneous water requirements because of the lack of uniform planting times, and diverting fertilizer to upland food crops. In the background pricing policy has varied from very favorable to vary unfavorable, depending on the country and the period.

Following reforms introduced in the late 1980s at the Office Du Niger in Mali, after 15 years of going nowhere, average system-wide yields for rice climbed from 2.2 tons per hectare in 1988/89 to four tons in 1991/92. This increase is attributed to rehabilitation of part of the infrastructure, strengthening farmer associations responsible for inputs and credit, introduction

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of higher yielding varieties, transplanting, more timely input availability, greater availability of credit, introduction of village level thrashing and processing technology, free markets and a minimum guaranteed price for rice. Average yields in one rehabilitated sector doubled from three to six tons per hectare in just three years (12).

4.B. Supportive public sector organizations and projects

Unlike the integrated marketing structures, public sector organizations and projects usually cover only part of the input/output system, cover the whole system more loosely, or cover marketing as only one of many responsibilities. They cover a wide range of agricultural input activities including seed distribution, extension services, input supply, and credit, among others. Sometimes they are autonomous, sometimes part of the administrative and technical services. For brevity we refer to these collectively as public marketing organizations, even though their functions usually go beyond marketing. These would also include parastatals that do not undertake integrated production and marketing activities.

In terms of effectiveness, public marketing organizations suffer from many of the problems of government funded institutions in Africa: inadequate resources, cumbersome financial controls, rigid budgetary cycles, and poor discipline and morale. How effective they are in providing inputs critical to adoption of improved technologies depends on many factors. In general, they succeed in getting inputs closer to farmers by using administrative distribution systems.

Two factors greatly condition how public marketing organizations affect technical innovation and progress in Africa: the quality and effectiveness of management, and whether the organization has a monopoly. If the former is good, the latter may not matter a great deal. But in the more likely case that the former is not very effective, having a monopoly prevents the private sector from picking up the slack.

Though monopolies may be necessary to attain critical economies of scale or recover high fixed investment costs, they encourage inefficiency and unresponsiveness. By eliminating competition monopolies lose an important standard against which to judge their performance. On the other hand, with open markets, competition can stimulate a public sector entity to improve performance. As Schmid points out, monopolies have their place but you have to know when to abolish them (24).

Public marketing organizations tend to focus on low-costs for consumers (first) and farmers (second) rather than on the cost of providing inputs and services in a timely manner. This often leads to subsidies that discourage private sector involvement almost as effectively as a monopoly. To the author, monopolies and over-concern for consumers appear to be greater impediments to effective and responsive input markets in the francophone than in the anglophone countries.

Public marketing organizations are usually subject to public sector or donor budget processes and financial controls, with all of the delays this implies. Not infrequently this leads to delays in making inputs available for critical operations. Where they are more autonomous, as with World Bank area development projects, input supply is generally much more reliable and technical progress more rapid. But those projects frequently fail to give adequate attention to developing private sector intermediaries which could maintain input supplies following project completion.

The ability of public marketing organizations to influence farmers' decisions to adopt new technologies varies. Where the organization maintains disciplined applied research and extension programs, it has more control and usually is more effective in spreading profitable technologies. Autonomous area development projects again come to mind. Where extension is weak or undisciplined, as with many of the rice perimeters in the Sahel and with ministries of agriculture in general, progress is slower, if measurable at all.

In general, public marketing organizations lack sensitivity to farming systems constraints. They tend to have a singular focus according to their primary purpose, be it seed production and marketing, coffee or rice production and marketing, or intensive livestock production and development. They tend to measure accomplishments by measuring services and products delivered, or changes in the output of single commodity, instead of changes in the marketing system or in the output of the farming system as a whole. In essence, they try to get farmers to conform to the needs of the project or organization rather than the reverse. This can lead to problems with adoption.

Development projects usually work with other public marketing organizations in executing their mandate. Consequently they also suffer when a key organization is ineffective. If the agency responsible for importing fertilizer fails to get its order in on time, organizations responsible for providing production and extension support can't do their job effectively.

In numerous instances partnerships between public services and private business have proved effective. This approach appears to be particularly promising for seed production and distribution. For example, a private seed production coop in Zambia does a very good job multiplying and marketing improved varieties developed by the national research system. Other countries are experimenting with or implementing programs relying on contract seed multiplication from both larger commercial farms and small farmers. CFDT and its affiliated national programs do a good job of combining the profit incentive of the private sector with extension and research of the public ministries.

In the past the stimulus for developing private-public partnerships appears to have come primarily from the private sector. This does not have to be the case. A NARS outreach program that identifies potential beneficial linkages and solicits private sector participation could add significantly to the effectiveness of the technology transfer process.

4.C. Cooperatives and farmer associations

Cooperatives in the francophone countries are very different animals than in the anglophone countries. In the former they tend to be instruments for exercising government control over farmers. In the latter they seem to be much more independent of government, dynamic and a powerful political force in their own right. This difference explains why cooperatives appear to have been more successful in the anglophone countries.

Although coops in all countries are subject to manipulation by prominent local leaders, they generally are more responsive to farmers concerns than public marketing organizations. They have proven effective in providing specialized services such as seed/plant production, input supply, pest management, seasonal and long-term credit, and higher quality processing and storage for their members. Cooperatives are probably most effective in providing marketing support.

Coops that are actually controlled by their members can be flexible and responsive to their members' concerns with respect to the range of services provided by the coop. Because of their structure and active participation by member farmers, they can provide an effective vehicle for disseminating research and technology, and a demand driven focus for research programs. The Kenya Cooperative Creameries (KCC) and Kilimanjaro Native Cooperative Union (KNCU) are examples from East Africa of effective cooperatives that provide most of these functions reasonably effectively for the dairy and coffee industries, respectively.
The ability of coops to do all of this depends on the effectiveness of their management in important measure, and on the effectiveness of the other marketing institutions on which they must rely. This varies widely even within the same country and between cooperative societies established the for same functional purpose.

Problems with coops in the francophone countries are typified by the peanut coops in Senegal, reviewed in a recent ART draft report (7). Originally established to further expansion of groundnut production following independence, the coops provided credit for seasonal inputs, animal traction equipment and equipment for harvesting and cleaning peanuts. They also serve as the focal point for extension on groundnuts.

The peanut coops in Senegal were responsible for the transformation of peanut production technology from one based mostly on manual labor at independence, to one in which virtually all peanuts are planted with animal drawn mechanical seeders. The seeders broke a land preparation and seeding bottleneck and allowed an expansion of the area planted. Large numbers of animal drawn cultivators, plows and carts were also purchased over this period, as a seeding constraint gave way to a weeding constraint.

The mechanization of peanut production in Senegal was influenced in important measure by the availability of credit and how the credit program was structured, but not in the way one might think. A general lack of discipline with respect to repayment led to a rapid increase in credit used for oxen, equipment and fertilizer in the 1970s. This eventually led to so much

unpaid credit that the government forgave all debts for agricultural credit and started over. The first time this occurred was near the end of the Sahelian drought.

During the 1980s the process repeated itself in a somewhat different form. Credit was still easily available and subject to abuse, but supplies of seed and fertilizer became unreliable because of the cumbersome operation of parastatals responsible for supplying these inputs. The coops had no real market power and there were no other sources of supply; so production fell and impaired the debt repayment capacity of farmers. Eventually, in the early 1990s the government froze all credit and, once again, inputs were available only for cash.

Throughout all of this the cooperatives were on the receiving end rather than on the acting end of government policy. They were not free to organize alternative sources of supply, and did not have access to credit except through the parastatals. Again, their purpose was not to become a dynamic engine of growth, but to execute the government's peanut policy.

Farmer associations and farmer groups represent a more recent attempt to organize farmers for meeting their own economic needs, inputs and credit being only two concerns. Credit unions, village committees, formal work groups and family groups are organized in a myriad of ways, some of which are effective and some not. SSA has accumulated a rich body of experience, especially in the anglophone countries, that is begging for research to identify what works and why. This is a promising area of research for the NARS outreach programs.

4.D. Other formal private systems and agri-business

In most African countries the formal private marketing system and agri-business input marketing organizations have weak links with the smallholder subsector. In the countries with more developed agricultural sectors, the formal private system is providing veterinary services and inputs, extension services, artificial insemination, fertilizer, seed, agricultural chemicals, pest control services, livestock feed, tractor hire services, equipment manufacturing, agro-industries and marketing infrastructure of all types, mostly geared toward commercial farmers and contract producers. In those countries with less developed agriculture there are many fewer such organizations, and those that exist are less dynamic and more concentrated in large towns.

Strong market demand is the catalyst for dynamic formal input markets and agri-businesses development. It facilitates formation of farmer associations which can then assume some input supply functions for their members. Input suppliers even have an incentive to supply extension services so as to increase the use of inputs, once production reaches a certain level.

The formal private market system is the most sensitive to bad policies, since it can not avoid their impact as well as public marketing organizations, development projects and informal markets. It will get involved in input supply only if there is a financial incentives to do so.

Where the government exercises close control of commercial activities in agriculture, the private sector will be reticent to become involved as more than an order taker.

Packaging and repackaging inputs is one area where formal private marketing systems has been active, but which requires further development in several countries in SSA, especially those with relatively few large farms. Ten and 25 kilo bags of fertilizer and bulking down agricultural chemicals, especially for horticultural products, would probably stimulate use of these products considerably. The issue is, perhaps, more one of affordability than quantity required. But initially, at least, many farmers find the cost of a 50 kilogram bag of fertilizer more than they care to risk. The problem with repackaging is what it adds to unit cost for the input.

In the future, there appears to be considerable potential for developing private sector participation in delivering veterinary services and products to farmers. Access to veterinary products provides an income source, provided the public sector is not subsidizing the products it distributes through the technical services. As civil servants trained in veterinary sciences retire and search economic opportunities one would expect them to link up with lower paid veterinary technicians and begin providing such services in economically important areas of the country.

4.E. Nongovernmental organizations

In the past five years, nongovernmental organizations interested in supporting agricultural development have mushroomed. The fiscal crises in many countries and changing employment policies have made employment in agriculture seem more appealing. The increase in funding by USAID for nongovernmental organizations as a way of expanding the role of the private sector has not gone unnoticed, either. Projects are now starting to use more nongovernmental organizations to implement field level activities among farmers. The devaluation of the CFA will most certainly provide a major stimulus for this type of activity in the CFA zone by cutting real wages in urban areas still more.

As used in Senegal, nongovernmental organizations tend to be led and staffed by relatively well educated secondary and university graduates. Their staff can communicate well with project staff, and are usually able to communicate easily with farmers in their own language. They are willing to live in rural areas, and seem to have a genuine concern for assisting and empowering the rural population.

Nongovernmental organizations usually have a modest base of permanent support. Consequently, they promise to have a more enduring commitment to development and greater continuity in rural areas than development organizations. Because of this they appear especially suitable for organizing farmer associations, helping these associations build infrastructure, obtain credit from financial institutions, order inputs, and provide advice on the proper use of technology.

4.F. Informal marketing system

Informal markets can be quite dynamic if extension and research is supportive, and farmers have free access to inputs. Prices for food and livestock products tend to be more affected by local supply and demand than by national price policy; so if the demand and inputs are there, informal markets tend to respond well in a wide range of policy environments. Informal markets are also quite skillful in circumventing policies that attempt to restrict competition or regulate market flows, as long as the quantities are relatively small. Moving larger quantities of goods will usually require involvement of the formal market structure, where the cost of avoiding onerous market controls is more difficult and more costly.

Sometimes it is not easy to distinguish formal and informal marketing systems. Usually they are operating together. In this paper, the informal marketing system includes most interfarm and local market exchanges, black market activities, and nonrecorded exchanges by unlicensed traders and merchants. Once a trader is licensed, he becomes part of the formal system and is subject to fiscal duties and other public sector regulations. Licensing is a formal process and designates a person as a professional trader. It is separate and distinct from someone who pays a fee to enter a permanent market in order to sell his/her wares or products.

Because they involve large numbers of participants, informal markets are more likely to be competitive and efficient. They also distribute closer to producing and consuming units. They lose some of their advantage when the nature or amount of the exchange requires an interface with the formal market structure. At that point their advantage reduces to one of lower distribution costs and availability closer to farmers.

Successful informal markets for agricultural inputs have a dynamic interface with the formal market structure. The formal market may be responsible for importing and packaging, manufacturing and distributing to larger towns. The informal market picks-up distribution somewhere from there on down, and is usually directed at small farmers rather than large commercial farmers. Output markets work the same way, but in reverse.

This doesn't mean that informal markets need a well developed formal market input delivery system in order to play a dynamic role in the technology transfer process. Indeed, informal markets have been a major player in transferring some of the most sustainable technologies built around open pollinated crop varieties and stabilized livestock production.

This has worked so well in some situations that farmers have given local names to crop varieties that, upon more careful examination, are really improved varieties from a neighboring country. In the Mandara mountains in Cameroon, for example, farmers 15 years ago were using open pollinated sorghum varieties that originated in Nigeria to produce yields in excess of three tons per hectare with nothing more than an adequate supply of manure (29).

Traditionally many researchers and farming systems economists have urged that research directed at small farmers concentrate on open pollinated varieties. With open pollinated

varieties small farmers can maintain their own seed supply or obtain good seed locally instead of having to rely on poorly developed input markets and unreliable seed multiplication programs[2]. This research has been especially successful with sorghum.

There is no doubt that informal marketing systems can make a significant difference in the effectiveness of input markets. Improved seed moves through informal channels and across national frontiers as easily as people do. Farmers are always on the lookout for new opportunities; a few seeds in the pocket, and a new enterprise is born, or an old one upgraded.

In most cases it seems that informal marketing systems need some catalyst before beginning to play an important role in supplying essential agricultural inputs. This suggests that development projects need to make development of local supply and demand for critical inputs an integral part of project activities.

On-farm seed production, for example, is becoming more common as a link between informal and formal market systems, and can provide a measure of social control over seed quality if producers supply mostly nearby farmers. It's also one way to expand the production and distribution capability for open pollinated seed. Of course this will only be possible where a viable national seed program or a private sector company can supply breeder or basic seed for on-farm multiplication, and can provide a measure of quality control. In countries with a more developed agriculture, seed certification and product differentiation will allow farmer produced seed to serve formal channels on a wider scale. Farmer pesticide applicators have proven quite effective for coffee in Rwanda.

Some thought must be given to the question of packaging and inventories for informal markets to play a dynamic role in technology transfer. For products that are easily recognized by farmers, c.f. most fertilizers, small tools and equipment, mineral salt and treated seed, informal market merchants can buy in bulk and then sell using local measures. This holds marketing costs to a minimum. But for such things as crop storage chemicals, seed treatment, some fertilizers, feed supplements and any other input that could be adulterated, factory sealed containers are more appropriate. Of course, this adds significantly to costs for small farmers who use only small quantities.

Inventories are more of a problem for merchants operating in informal markets. Many have very little storage capacity, and none want to hold unsold seasonal inventory until the next cropping season. Many seasonal inputs would deteriorate in quality to an unacceptable degree

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[2]Although this approach has worked well, a recent study by Byerlee and Heisey (5) suggests that it may not be altogether appropriate to ignore hybrids for maize technologies directed at resource-poor small farmers, even where intercropping is involved. The authors cite numerous examples of research results that show that, in many situations, hybrids produce substantially higher yields than local varieties even under moisture stress conditions with no fertilizer. Farmers in many East African countries who have been using hybrids in this way are obtaining higher returns than with traditional varieties.

under the poor storage conditions typical of informal markets. Providing for withdrawing unsold inventory after a specific date would solve these problems.

It is most difficult to link informal market systems with credit because of the inability to assure repayment if participants do not know each other. Where markets participants are known to each other viable village credit associations and similar institutions can mobilize the necessary capital. Merchants also may be willing to lend, or sell at a premium, to farmers who do not have sufficient cash to acquire the inputs they need. In this regard stockist credit programs similar to those which existed for improved maize in Kenya in the mid-seventies might succeed in interjecting more credit without having to set up a costly program directed at small holders.

By their very nature, informal market participants do not have much power to influence research. Nor will they generally invest the resources necessary to develop demand. Informal markets are also not very reliable providers of inputs requiring technical sophistication for proper use, unless support services are available from elsewhere or farmers already know how to use them. But these market systems will respond to demand for inputs and technologies once the demand is established.

Shallow well irrigated onion production in Niger provides one of the more remarkable successes of an informal marketing system. With very little support from the traditional extension system, and relying almost entirely on inputs smuggled into Niger from Nigeria, this industry doubled production over the ten years ending in 1992, reaching an estimated 200,000 tons. Eighty percent of this output is exported, making it a more important earner of foreign exchange than cattle and small ruminants in most years.

Fertilizer, small motor-pumps, spare parts and agricultural chemicals are smuggled into southern Niger from Nigeria. Local farmers specialize in seed production, local craftsman dig the wells and, increasingly, line them with cement. And entire villages organize transportation to Niamey or to coastal cities where onions are in high demand (28).

Cooperatives and larger farmers construct traditional storage facilities and season and store onions for sale during the off season when prices are two to three times higher. Smaller farmers dry some of their production in order to obtain the higher price of the off-season. Local merchants buy from individual farmers and sell in truck load lots along the road. Truckers come from as far away as Abidjan to purchase for their own account, or to haul for merchants who don't have their own vehicles. All of this has occurred with negligible government assistance.

Cassava throughout tropical and subtropical Africa, potatoes in the highland areas of East and Central Africa, hybrid maize in Eastern and Southern Africa, rice in Madagascar and rice and maize in West Africa provide other examples where informal markets have either led or supplemented project based and formal market systems in diffusing technologies that sharply increase yields.

5. A case study in developing input markets: the SZWMP

The Southern Zone Water Management Project in Senegal will reclaim and improve 15,000 hectares of rice land in the Casamance region of Senegal. When it was originally designed the project did not provide for input supply, credit or extension. It was designed at a time when reforms in input supply and extension were underway that were expected to lead to a viable market for inputs and to an improved MOA extension service that would serve the project. By the second year of project implementation neither result had occurred. The original project also included a component for nongovernmental organizations to help with completion of infrastructure development following construction of water control dikes.

To rectify the problem of input supply and extension USAID agreed to expand the mandate of the nongovernmental organizations. They are to work in each valley for four years, completing construction of the infrastructure, organizing farmers for operating and maintaining the water works, organizing village associations, teaching farmers how to use the improved rice production technology promoted by the project, and helping villagers establish and manage a revolving fund for dike maintenance and input supply. To constitute the revolving fund for inputs, farmers in some valleys are to repay into it the cost of tractor plowing donated by the project in the first year following completion of construction. In other valleys farmers have agreed to deposit 25-35 percent of the wages earned on construction of the dikes into the revolving fund.

Farmers in the first two valleys developed by the project participated in farmer managed demonstrations of several rice varieties during the year the dikes were being constructed (1993). In that year they were given all inputs free. Yields from those parcels averaged 2600–3000 kg/ha of paddy, versus an estimated 600-1200 before the project. The increase is due to a combination of better water control, use of fertilizer and some pesticides, and new varieties. Following results for the first year, interest in the new technology was keen.

In 1994 separate nongovernmental organizations began working in each of the two valleys. Nothing was planned for the revolving fund for 1994, since it was to be constituted from repayments out of the harvest. However, one of the nongovernmental organizations is very dynamic. It has arranged for credit for 1994 by getting farmers to contribute the down payment from their own funds. In the other valley, inputs were made available only for cash. The project arranged to transport the inputs for both valleys from the regional town where the nearest supply was located, about 125 miles away from the more distant valley.

The inputs were distributed and sold by the village committee, working with the nongovernmental organization. The committee charged 10 percent over cost for cash, and 15 percent over cost, plus interest, on credit purchases. Farmers will be able to repay their credit in kind. As soon as the revolving fund builds up, the village committee will hire its own half-time extension agent, to be paid 15,000 FCFA/mo from the margin added to the cost of inputs. In the first year farmers in the valley with the revolving fund ordered enough fertilizer to fill a 25-ton truck. If all of the credit is repaid the village committee will earn 250,000 FCFA, plus

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interest, from the first year's fertilizer sales alone. The goal of this part of the project is to have the village committees operating the water control gates, the credit and input supply program, and the extension program, without further support from the nongovernmental organization, by the end of the fourth year.

In this example of developing an informal market input supply program managed largely by farmers, many of the details are still evolving. There is still a problem at all levels with people who want to "help" farmers with cheap inputs and credit. Farmers have not yet had to repay the first year's credit so we are not sure how effective the nongovernmental organization's work with the village committee will be with repayment. Perhaps most importantly, following the devaluation of the CFA by 100 percent, Senegal increased the price of imported rice to consumers by only 6 percent, while the price of fertilizer went up by 50 percent. At the present time the price of rice to farmers is only about 65 percent of its value to the Senegalese economy. This is certainly not a hospitable macro policy environment for a test of this approach to delivering new technology to small farmers.

Apart from an adverse price for rice, most of the farm level elements for a successful transfer of technology and privatization of extension are here: a demonstrably viable technological package, an autonomous informal market private sector input supply program in a resource poor environment; a capable extension service financed from input sales; and credit. Hopefully, before farmers generate a surplus beyond their own needs the price of rice will move closer to import parity and provide a viable market for surplus production.

Most of this would not have happened without adding to the project an explicit goal of developing input markets. The gap between the formal private market system and the informal market system was simply too large. In my opinion, such gaps, more than anything, explain the slow transfer of technology in much of Africa.

6. Increasing the efficiency of input markets in sub-Saharan Africa

6.A. Actions that work

Attention to market development in projects. Development projects need to make development of input markets and private sector involvement an explicit project goal and design parameter. Without concrete action to stimulate private sector involvement in input markets, many viable technologies will not spread or will spread slowly for want of a reliable supply of essential inputs. It does little good for projects themselves to assume the input distribution role unless this is part of a larger plan to transfer this function to the private sector during project implementation.

Policy reform aimed at marketing margins. Subsidies in the form of below cost marketing margins should either be eliminated or made available to private sector intermediaries so they can compete on an equal footing. Better yet, parastatals should act as suppliers of last resort, at a price well above of the cost at which the private sector can respond. This allows the private sector an opportuniy to expand and establish supply lines, while public marketing systems provide a check on any price gouging that might be attempted. Once demand develops enough to warrant merchant purchases in truckload lots, the private sector stands a good chance of continuing to provide an efficient source of inputs for farmers.

Policy reform aimed at illicit enrichment. This is a cancer that infects much of Africa. The best control is to force a reduction of road check points and to empower farmers to provide input services themselves. Of course, governments really wishing to correct such problems could always give merchants and farmers a right of private action against offending public employees, with the right to collect damages by attaching monthly salaries where they are found guilty by the courts.

Add an outreach component to national research programs. Too often research stops with the development of new technologies. When the entities responsible for diffusion of the research are weak or inputs are not available, the technology remains dormant. Giving national programs an outreach capability, perhaps through regional teams composed of outreach staff from the individual NARS, would help promote available technology. The outreach program could be charged, among other things, with trying to interest local capital in producing or packaging the required inputs, finding merchants who are willing to stock needed inputs, and providing the extension service, nongovernmental organizations and, perhaps the larger farmer associations with training in the use of the new technology. It should certainly be charged with disseminating research results as widely as possible, making sure several hundred copies of key reports are distributed to all parties of likely or potential interest, including private sector entrepreneurs and input suppliers.

6.B. Priority issues for research on input markets

Because many of the researchable issues relating to input markets are similar for a number of African countries, the accumulation and transfer of knowledge about them would benefit from regional collaboration. Experience in one country could more immediately benefit another country with a similar situation. Agricultural economists trained by USAID in past projects and programs would provide an ideal cadre for staffing such programs. The topics suggested below should relate to, and reinforce, the regional technical research program as much as possible.

6.B.1. Impact of government policies and regulations on input markets

The range of topics here is quite large and would include many of the points raised in this report. The effect of a particular subsidy program on development of input markets and how it might be improved, disruptions in the availability or quality of inputs that result from government policies and how they can be avoided, and the effect of output pricing policy on the use of a particular improved technology are examples of timely topics.

6.B.2. Farmer associations and other small group methods for delivering agricultural credit to resource poor farmers

A number of approaches to delivering seasonal and other agricultural credit are being tried throughout Africa. Some of the more promising are based on farmer groups, with assistance from nongovernmental organizations. What are the criteria for identifying a successful and sustainable program, and what are the characteristics of successful programs in the countries covered by the regional research network? Having an economic interest in the results and a long-term commitment to the program, will, no doubt, prove to be key ingredients in the success an nongovernmental organization has in working with farmer associations.

6.C.3. Farmer managed and farmer financed input delivery systems

This topic requires an approach similar to that for credit, but focusing on inputs other than credit. Because of its importance for the proper and economic use of inputs, this study should cover extension as well as physical agricultural inputs. Small farmer seed production, farmer executed integrated pest management and farmer led pest treatment programs would be other suitable topics. Again, the focus should be on finding farmer managed approaches that facilitate the technology transfer process.

Notes

1. Bal, Sharanjit S. and Johnson E. Douglas; 1992; :Designing Successful Farmer-Managed Seed Systems; Winrock International Institute for Agricultural Development; Morrilton.

2. Blackburn, Harvey and Cees De Haan, Editors; 1993; Livestock Development Projects: Past Present and Future; Proceedings of an Informal Meeting of Donor Representatives Involved in Livestock Development, Organized by USAID and The World Bank, Paris, 4-6 December, 1992.

3. Blase, Melvin G.; 1993; An Analysis of Funding Alternatives for Agricultural Research With Special Reference to Africa; Columbia.

4. Boughton, Duncan and Bruno Henry de Fran; 1994; Agricultural Research Impact Assessment: The Case of Maize Technology Adoption in Southern Mali; Office of Sustainable Development, Bureau for Africa, USAID.

5. Byerlee, Derek and Paul Heisey; 1993; Performance of Hybrids under Low-Input Conditions in Eastern and Southern Africa;

6. Catterson, Thomas M.; 1994; Integrating Natural Resource Management Concerns into Agricultural Research in sub-Saharan Africa: A Position Paper; Tropical Research and Development, Inc.

7. Christensen, Cheryl; 1994; Agricultural Research in Africa: A Review of USAID Strategies and Experience; Technical Paper No. ?; Office of Analysis, Research, and Technical Support, Bureau for Africa, USAID. Draft report, not for citation.

8. Crawford, Eric W.; 1993; Constraints to the Development and Use of Improved Technology; Department of Agricultural Economics, Michigan State University, Staff Paper No. 93-64.

9. Fabiola, Hyacinthe, et al.; 1990; Etude sur les Engrais Mineraux et les Pesticides au Rwanda; Ministère de l'Agriculture, de l'Elévage et des Forêts, Division des Statistiques Agricoles; Kigali.

10. Gilbert, Elon et al.; 1994; Maize Research Impact in Africa: The Obscured Revolution; Office of Analysis Research and Technical Support, Bureau for Africa, USAID.

11. The Indonesian National IPM Program; Farmers as Experts. Undated

12. Kante, Bakary; 1993; Fax to Josué Dione, MSU regarding data on productivity growth in rice in Mali.

13. Lesser, W.; 1992; Agribusiness and Public Sector Collaboration In Agricultural Technology Development and Use in sub-Saharan Africa: A Synthesis of Field Studies; ABT Associates; Bethesda.

14. Matlon, P. et al.; 1994; Achievements in African Rice Research; West African Rice Development Association (WARDA).

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15. Meltzer, Martin; 1994; Sustainable African Agriculture Technology Systems: Livestock Position Paper; Tropical Research and Development, Inc.

16. Ministère de l'Agriculture, de l'Elévage et des Forêts; 1990; Résultats D'une Enquête sur L'Experience des Engrais Mineraux et des Pesticides en Milieu Rural au Rwanda; Division des Statistiques Agricoles; Kigali.

17. Oehmke, James F.; 1994; Achievements in African Agricultural Technology Development and Transfer; Office of Analysis Research and Technical Support, Bureau for Africa, USAID.

18. Oehmke, James F. and Eric W. Crawford; 1993; The Impact of Agricultural Technology in sub-Saharan Africa: A Synthesis of Symposium Findings; Technical Paper No. 3; Office of Analysis Research and Technical Support, Bureau for Africa, USAID.

19. Office of Analysis, Research and Technical Support; 1994; Proceedings of the Agricultural Technology Development and Transfer Collaborators Workshop held June 28-30, 1993; USAID, Bureau for Africa; Washington, D.C.; Draft report, not for citation.

20. Office of Analysis, Research and Technical Support; 1994; Strategic Framework for Agricultural Technology Development and Transfer in sub-Saharan Africa; Technical Paper No. ?; USAID, Bureau for Africa; Washington, D.C.; Draft report, not for citation.

21. Office of Analysis, Research and Technical Support; 1993; Towards a Sustainable Future for Africa; Technical Paper No.5;
USAID, Bureau for Africa; Washington, D.C.

22. Plucknett, Donald L.; 1994; Agricultural Research and Technology Innovation in Africa: Organizational and Financial Concerns; Agricultural Research and Development International; Annandale.

23. Ross, Jack; 1994; Sustainable African Agriculture Technology Systems: Fruit and Vegetable Position Paper; Tropical Research and Development, Inc.

24. Schmid, A. Allen; 1992; Legal Foundations of the Market: Implications for Africa; Paper prepared for PRISAS Workshop on Institutional and Legal Environment of Agricultural Input and Commodity Markets in the Sahel, Bamako, March 22-28, 1992.

25. Tinsley, R.L.; 1994; Sustainable African Agricultural Technology Systems: Rice Production Position Paper; Tropical Research and Development, Inc.

26. Tropical Research and Development, Inc.; 1992; Analysis of Private Sector Technology Transfer Methods.

27. USAID; 1994; Strategies For Sustainable Development; Washington, D.C.

28. Zalla, Tom; 1993; Selected Indicators for Measuring GON Performance in Agricultural Marketing, Fiscal Reforms, Democracy and Strategic Objective Indicators; ABT Associates/APAP II; Niamey.

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29. Zalla, Tom, David Campbell, John Holtzman, Larry Lev and David Trechter; 1981; Agricultural Production Potential in the Mandara Mountains; Rural Development Working Paper No.18, Department of Agricultural Economics, Michigan State University; East Lansing.

30. Zalla, Tom, Nicolas Kulibaba and Peter Watson; 1988; Togo Animal Traction Development Project: Final Evaluation Report; Development Alternatives, Inc.; Lomé.

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An examination of intellectual property rights in sub-Saharan Africa position paper

by

Dave D. Weatherspoon

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Acronyms

ARIPO	African Regional Intellectual Property Organization
OAPI	Organization Africane de la Propriete Intellectuelle
IP	Intellectual Property
IPR	Intellectual Property Rights
PBR	Plant Breeder's Rights
PCT	Patent Cooperation Treaty
R&D	Research and Development
SSA	Sub-Saharan Africa
UPOV	Union for the Protection of New Varieties of Plants
WIPO	World Intellectual Property Organization

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Glossary

ARIPO: A regional intellectual property organization (African Regional Intellectual Property Organization) originally called ESARIPO where the ES stood for English speaking. Formed in 1976 with 12 member countries (Botswana, Gambia, Ghana, Kenya, Malawi, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe).

Berne Convention: An international copyright convention negotiated in 1886 and revised in 1971 and is administered by WIPO.

Budapest Treaty: A treaty on Microorganisms (1977) that provides for an international depository in several nations for patented microorganisms (treaty lowers the cost of depositing multiple samples in each country the inventor desires protection).

Copyright: The protection of original artistic or literary works.

Intellectual Property: A general term applied to forms of property (patents, trademarks, and copyrights) that derives from creative efforts and grant exclusive rights to the innovator.

OAPI: A regional intellectual property organization (Organization Africane de la Propriete Intellectuelle), formed in Libreville 1962 and revised at Bangui, 1977. Thirteen Francaphone country members (Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Cote d'Ivoire, Gabon, Mali, Mauritania, Niger, Senegal, and Togo.

Paris Convention: An international convention on industrial property rights (1883) that assures equal treatment to member countries and creates a means of determining priority between competing claims. The latest update was in 1967 (Stockholm).

Patent Cooperation Treaty: A uniform application that provides uniform protection for citizens of different countries. Thirty-five countries signed original treaty. Thirty-five countries signed, it is intended to accelerate the economic development of developing countries through the adoption of measures designed to increase the efficiency of their legal system.

Patents: Allows the owner the right to prevent others from making, using, or selling their invention. This time limited monopoly (if exploited) is usually granted for 15-20 years depending on the country.

Petty Patents: Minor mechanical adaptations, especially with agricultural implements. Also know as Utility Model laws in some developing countries.

Piracy: The unauthorized use of patents, trademarks, and copyrights.

Plant Breeder's Rights: Protection of nonhybrid plants

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Service Marks: A mark used in the sale or advertising of services to identify the services of one person and distinguish them from the services of others.

Trademarks: A word, name, symbol, device, design, slogan, or sound which distinguishes a product or service from a competitor's is considered a trademark.

UPOV: The Union for the Protection of New Varieties of Plants (1961) provides protection (15-18 yrs. depending on the type of plant) to breeders from member countries for reproductive or vegetative propagating material. Authorization is required for commercial use but not for experimental use.

Utility Model: A patent-like right issued in some nations to inventions which fail to meet the standards of technical progress necessary to qualify for a patent.

WIPO: The World Intellectual Property Organization. WIPO was formed in 1963 to administer several of the major intellectual property conventions (i.e. Berne and Paris).

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Executive summary

The commercialization of agricultural technology in sub-Saharan Africa is an important factor that should increase: the adoption of new technology, output, regional and international trade, and economic growth. However, before commercialization can take place the proper intellectual property laws must be implemented and enforced. Multi-national firms and local African firms are unwilling to invest in research in sub-Saharan Africa for two main reasons: weak intellectual property rights and the market size or potential.

There has been a long lasting debate between industrial and developing countries concerning intellectual property rights.

Many developing countries believe that knowledge should be made available at a minimal cost to them because the economic development of an impoverished country benefits the world. The industrialized countries rely on the returns from research and development (R&D) and believe that if these returns are not forthcoming less research and development will be conducted which is a detriment to the world. The estimated overall annual loss in revenue due to pirating of U.S. technology alone is close to $61 billion.

Sub-Saharan Africa will face greater pressure in the near future to strengthen their intellectual property laws. Without a change in policy, technology will not flow to Africa or within Africa. The low utilization of high yielding crop varieties and other modern technologies is thought to be a major reason for the slow agricultural productivity rate and economic growth rate. There are however, arguments against the harmonization of intellectual property laws. One is that harmonization may not be socially optimal for developing countries. Several factors should be considered concerning harmonization: the nature of protection instruments to be adopted for particular technologies, the suitability of local economic and technological conditions, and any additional measures that may be needed to ensure that intellectual property protection serves broader social and economic purposes. Presently, most countries follow a system that minimizes conflict and the probability of trade retaliation.

In addition to the international forces to strengthen property laws, the international donors have continued to reduce their level of support to sub-Saharan Africa. These countries will have to look to indigenous sources of funding. The marketing of regional and international technology is most likely their best choice. Prior to commercialization however, the proper intellectual property laws must be implemented and the current national laws that are not based on free market principles must be re-examined.

One approach that is suggested in this paper to strengthen the intellectual property laws is to encourage and promote the two current intellectual property organizations in sub-Saharan Africa; the African Regional Intellectual Property Organization (ARIPO), and Organization Africane de la Propriete Intellectuelle (OAPI). The resources needed to operate a intellectual property office in terms of human capital is more than most individual African countries can

afford. With the regional system, resources are pooled, but the laws are still national in nature which protect the sovereignty of nations. This should allow for cost effective and efficient services for patent searches and etc.

Three other general suggestions were also made in the body of this paper. The first was to determine the best way to encourage residents of sub-Saharan Africa to become familiar with and use the intellectual property laws. It was found that the residents of sub-Saharan Africa were primarily familiar with or used trademarks and not patents or industrial designs. This may be a factor of educating people about the options of protecting their inventions or a factor of the expenses to successfully obtain a patent. Presently, these inventors may be using trade secrecy as their method of protection. The second suggestion was to strengthen the IP laws to encourage R&D firms to locate in sub-Saharan Africa. The firms sampled by Mansfield indicated that they would not locate a research institute in any developing country unless the proper intellectual property laws were in place and enforced. Thirdly, it was suggested that the process to file and receive patents, trademarks, and copyrights be expedited and simplified. This could be done by creating a group similar to the British Technology Group for sub-Saharan Africa.

Lastly, while noting the problems of sub-Saharan Africa, it is necessary to note that the U.S. has problems even though there are several intellectual property rights laws that protect plant breeders. There are several loopholes in which the plant breeders lose critical revenue in the system. The research and farmers seed exemptions are the main source of their losses. This lost revenue could have been reinvested in research or simply used to reward the efforts of the innovators. If there are no rewards to research, then less research will take place over time no matter what country in involved.

Introduction

The lack of economic growth in sub-Saharan African countries is believed to be associated with several factors. One factor is the slow growth in the agricultural sector's productivity which is a main source of foreign currency for many developing countries. The low utilization of high yielding varieties and other modern technologies is a major reason for the slow productivity rate. In many cases, the lack of use of modern technology is not due to the resistance of farmers, but due to the lack of availability of the technology. Most multinational and foreign firms are reluctant to invest in sub-Saharan Africa because of their insufficient intellectual property laws.

In general, developing countries do not enforce or have sufficient intellectual property laws in comparison to industrialized countries. This asymmetry has caused unnecessary tension and a lack of cooperation between the developing and industrialized countries. Although difficult to measure, the annual loss in revenue due to the pirating (unauthorized use) of technology for U.S. firms alone is close to $61 billion (Lesser, 1991). This figure includes the violation of patents, copyrights, and trademarks in countries with and without intellectual property laws. Intellectual property laws are obviously important to research and development firms around the world. Without intellectual property rights laws it is difficult to commercialize a product once it has been developed and determined to be profitable.

Intellectual property laws will become more important to developing countries as world trade and the amount of technology embodied in these products increases. These countries will have to increase their intellectual property laws or else the technology boom will "pass them by." Another factor that will influence the move for stronger intellectual property laws is the dramatic reduction in funding to sub-Saharan Africa by international donors. The potential for some sub-Saharan African countries to gain is enormous as their national and regional research capacities increase.

This paper is organized into five topics concerning sub-Saharan Africa and intellectual property rights. First, the historical and existing laws are reviewed. Second, the harmonization of national and regional laws with international laws versus keeping a differentiated system is discussed. Third, a brief discussion of the inputs market is given. Fourth, the issues concerning the commercialization of inputs and final products are reviewed. Lastly, before the suggestions and conclusions are given, the U.S.'s experience is included as a potential guide.

Intellectual property laws in sub-Saharan Africa

Historically, there were major differences of opinion on the value of intellectual property rights (IPR) in industrialized and developing countries. Many developing countries believe that knowledge should be made available at a minimal cost to them because the economic development of an impoverished country benefits the world. The industrialized countries rely

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on the returns from research and development (R&D) and believe that if these returns are not forthcoming, less research and development will be conducted, which is detrimental to the world (Mansfield, 1993; and Maskus, 1993). Presently, this debate continues.

Fortunately, there is some activity with respect to IPR in sub-Saharan Africa (SSA) according to several World Intellectual Property Organization (WIPO) employee's. Several of these countries have either joined regional intellectual property (IP) organizations or are attempting to harmonize their laws with WIPO's. This is encouraging news for researchers in SSA and to industry in industrialized countries who are interested in the African market.

According to John Hawkins of WIPO, in a telephone conversation: Kenya, Malawi, and the Sudan have joined the African Regional Intellectual Property Organization (ARIPO) as of the first of July, 1994.[3] Swaziland will finalize its paperwork to be an official member of ARIPO by the 20th of September, 1994. In addition, ARIPO became part of the Patent Cooperation Treaty (PCT) as of June 9, 1994. PCT is a multilateral treaty where someone files a PCT application in one country and 30 months later it becomes a national patent in the rest of the PCT countries. In general, several countries in SSA are updating their laws with respect to industrial and mechanical property.

In terms of plants and animals there is much to be done. According to Andrea Heitz (WIPO, Director of the International Convention for the Protection of New Varieties of Plants), only three countries have legislation that could be harmonized with the International Convention for the Protection of New Varieties of Plants (UPOV).[4] Kenya, due to its IP laws historically being tied to Britain's, has had a law (Kenya's Seed and Plant Varieties Act, 1975) that is almost compatible with UPOV (one issue must be resolved) for several years. The problem is that they have not implemented this law (Juma and Ojwang, 1989). According to Kiriro and Juma (1991) the Kenyan farmers have sought alternatives to plant breeders rights (PBR) since the laws are inactive. For example, the flower producers, "fortress farms," use trade secrecy as a method of protection. A number of other countries in SSA also use trade secrecy as their method of protection (Swaziland, Zimbabwe, etc.).

Zimbabwe, although not a member of UPOV, has implemented a national law on plants, which is similar to South Africa's laws. South Africa is the only African country that is an official member of UPOV. Zambia, however, has shown interest in UPOV and has a draft legislation ready. It will probably take a few years for them to become a member of UPOV. No activity was reported for OAPI (Mr. Heitz, WIPO 1994).

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[3]There are two major IP organizations in SSA, ARIPO and OAPI. ARIPO represents 12 (originally) English speaking countries and OAPI represents 13 Francaphone countries.

[4]As a member country, the rights assigned to the breeders of new varieties have a mechanism of enforcing collection of royalties of domestic and foreign right holders. Second, as a result of being a member, the new varieties are promoted internationally (Horbulyk, 1993).

Concerning animal patents, Mr. Heitz (WIPO) expressed little hope that any African country would move to issue an IP law concerning them. He noted that only the Socialist countries in Europe have strong laws concerning animals. The U.S. only recently granted its first patent (1988) for a genetically altered animal (Juma and Ojwang, 1989).

In several other developing countries outside of Africa (Asia and South America), it is apparent that as the IPR laws increase, so do the number of patents filed. Table 1 illustrates what is occurring in Kenya, Zimbabwe, and OAPI over time as their IP laws are harmonized with the industrial countries. Unfortunately, this table does not represent what is occurring in the plants and animals because these countries either do not collect data regularly or do not give any breakdown for those categories (Ms. Simpson, WIPO).[5] However, patents are a good indicator of the current trends in industry worldwide.

Patents in SSA. Patent data in general point to a gradual move towards high tech activities and the characteristics of the international firms from industrialized countries. Table 1 shows the number of patents filed by residents and nonresidents as well as the number of patents granted in Kenya, Zimbabwe, and the OAPI. Apparently from the data in Table 1, the residents of Kenya are not active in filing patents. During the period of 1980 to 1992 the residents of Kenya have filed approximately nine patents and have been successful in getting three granted. Eight of the nine patents filed were filed in 1991. The nonresidents of Kenya filed on average approximately 100 patents a year with around 100 percent being granted each year from 1980–86. The success rate has dropped to around 50 percent for nonresidents from 1987–92. This change in the success rate may be due to the patents being filed in Kenya instead of London.

Zimbabwe's situation is encouraging in that the residents file on average approximately 40 patents a year. The success rate is somewhere below 50 percent for the residents of Zimbabwe. The nonresidents file almost four times as many patents yearly with a success rate fairly close to 100 percent. Over the time period 1980–92, the total number of patents granted appeared to be fairly stable.

The Organization Africane de la Propriete Intellectuelle (OAPI) represents 13 francaphone countries. If a patent is filed in one of the 13 countries it is active in the other 12 countries. The residents of the 13 countries file on average 20 patents a year which is just above one patent a year per country. Their success rate is nearly 50 percent on average. Over time the filing of patents peaked in the late 1980's for residents. Nonresidents have increased their filing dramatically every year. By 1992, just over 6000 patents were filed by nonresidents with 379 being granted. The number of patents granted each year to nonresidents has fluctuated, but appears to be increasing overall.

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[5]Animal Patents are not recorded because it is a new category for WIPO, and they make updates every five years to their system. The category that would probably include animal related patents is microorganisms (Ms. Simpson, WIPO).

Trademarks in SSA. In terms of trademarks, Table 2 indicates that residents and nonresidents are familiar with how to apply for and attain a trademark certificate. In Kenya, residents file just over 40 percent of the trademarks on average and receive around 30 to 40 percent of the trademarks. The overall trend in Kenya is a decrease in applications and licenses issued.

Zimbabwe's residents file 20 percent to 50 percent of the trademark applications each year. The overall trend appears to be an increase in applications filed since 1982 for residents and since 1987 for nonresidents. The applications granted trend lags behind the applications filed by one year.

Unfortunately, the data for the OAPI is incomplete. What is clear is that the residents do not use this method of protection. The number of trademark applications are fairly constant for residents and rebounding for nonresidents.

Industrial Designs in SSA. Table 3 illustrates that there is little activity in the area of industrial design applications by residents and nonresidents. Kenya has not reported this data for many years. In terms of Zimbabwe, there appears to have been no discrimination in granting patents. The OAPI may be different in that they may have a bias toward residents.

Summary. The 15 countries represented in this sample of SSA countries indicates that the residents are familiar mainly with the trademarks IP laws. Patenting and filing industrial designs must be encouraged in the residents of SSA to promote indigenous innovations. This may be a factor of educating the people about the options of protecting their inventions. Presently, these inventors may be using trade secrecy as their method of protection.

The other reason why patents may not be filed by residents is the costs associated with attaining a patent. The filing fees for ARIPO and OAPI are both less than a thousand U.S. dollars (WIPO, 1987). However, the lawyer fees associated with attaining a patent may add another $700 to $5000, hence making patenting by residents prohibitive (Meltzer, 1994). This range is dependent on the degree to which the applications are filled out.

Harmonization versus differentiation

The international differences in IPR protection have led the industrialized nations to push for greater uniformity of treatment of laws. These standards would provide strong protection for innovative firms from any country, without discrimination. The U.S. is one of the strongest supporters of the harmonization of IP laws worldwide.

Harmonization may or may not be the social optimum for developing countries. There are several factors that should be considered: the nature of the protection instruments to be adopted for particular technologies, the suitability of local economic and technological conditions, and any additional measures that may be needed to ensure that IP protection serves the broader social and economic purposes (UNCTAD Secretariat, 1989).

Presently, most countries follow a system that minimizes conflict and the probability of trade retaliation. Most SSA countries do not have the resources to pirate certain technologies. Therefore, no retaliatory measures have been taken against them. However, these conditions are changing and the potential for future trade retaliation by industrialized countries, if SSA does not strengthen its laws, is definitely within the realm of possibilities.

The following is a review of the arguments for both sides, differentiated IP laws and the harmonization of IP laws.

Differentiated laws. Some argue that the level of protection should be dependent on the level of development of the country in consideration. The more developed the country is, the stronger the IP laws and vice versa (UNCTAD Secretariat, 1989; and Frischtak, 1993). One scheme would be to separate the countries in SSA into three groups: extremely poor, poor, and nearly industrialized. The extremely poor countries may implement laws to protect easily copied products. The poor countries may have the resources to modify products. Hence, the utility model and licensing approach should be implemented in addition to basic IP laws. The industrializing countries should have the strongest IP laws available (Frischtak, 1993).

Facilitating economic growth will be difficult in extremely poor countries while simultaneously promoting foreign investment and technology inflow. It is important that these countries develop an indigenous technology base. These countries will have to make sure that the inflow of technology does not displace their local R&D efforts. However, to procure the inflow of capital or technology certain IPR laws will have to be strengthened.

Harmonization. The benefits and drawbacks of harmonization has been discussed for a number of years, most recently in the General Agreement on Tariffs and Trade (GATT) negotiations (Lesser, 1992; Sherwood, 1993; Boone and Mathieson, 1990; Mansfield, 1993; and Horbulyk, 1993). Harmonization is a popular theme for the industrialized countries since they have lost billions of dollars due to pirating.

Research has indicated that there is a relationship between development and IPR. The U.S. Department of Commerce lists the worst pirating nations of the world; this list is almost exactly the same as the list of countries that have the most development over the past 30-40 years (Evenson, 1990). The industrialized countries will use various methods such as trade retaliation to reverse the increasing trend of piracy.

Potential benefits of harmonization include the following:

- Boosts local private research
- Improved crop varieties
- Develops human resources
- New technology enters economy
- Increases local competition
- Stimulates local adaptive research

- Expands global research (R&D cost recovery)
- Stimulates Foreign Investment
- Stimulates Economic Growth
- Reduces the Brain Drain (i.e., given a competitive pay structure and/or incentives to innovators)
- Diminishes piracy

Potential Drawbacks of Harmonization

- Dependency of developing countries on industrialized countries
- Some technology inputs may cost more
- Increase cost of some final products
- Diminishing gene pool

Summary. Regardless of the potential drawbacks of harmonization, in order for SSA to develop and receive new technologies, they must have comparable laws with the industrialized countries.

Inputs market

Most countries in sub-Saharan Africa rely on agriculture for employment, food, and export earnings. None of these countries can take the chance of being excluded from new developments. Direct foreign investment by multinationals and other firms is extremely important for the transfer of most modern technology.

Mansfield (1993) surveyed 100 U.S. firms representing six industries (chemicals, transportation equipment, electrical equipment, machinery, food, and metals) about the effects of intellectual property rights on the transfer of technology to developing countries via direct investment. Their responses were dependent on the nature of the investment as indicated in Table 4. In terms of sales and distribution outlets only 20 percent of the firms indicated that IPR protection was important.

Investment in rudimentary production and assembly facilities invoked a larger response (33 percent) for the importance of IPR protection. A greater response was given for firms to invest in facilities to manufacture components or complete products in developing countries (50 percent). IPR protection was found to be the most important to firms investing in R&D facilities in developing countries (80 percent). Note the lower average for the food industry in comparison with the other five industries, with the exception of sales and distribution outlets.

Mansfield found three concerns that most companies expressed when asked if they would directly invest or become a partner with a local firm in a developing country. First, are the country's laws sufficient to protect their technology? Second, does an adequate legal

infrastructure exist in the country? Third, are the governmental agencies in the country willing to enforce the laws promptly and equably?

Low-value inputs. Low value inputs for this discussion refers to inputs that do not have a large enough market to interest large firms or multinationals. These inputs are best marketed by small to medium sized indigenous firms. This activity seems simple enough but without the proper policies in place, these technologies are usually never marketed.

The marketing or commercialization of these types of inputs are hindered where IPR laws are weak, not enforced, or cost to much to file. For example, if a firm in Swaziland discovers something new and begins to produce it, they know that they have no legal recourse if someone starts to produce the same product next door. Therefore, it is usually not worth the initial investment to try to commercialize a product without the proper protection in place.

Assuming a firm wants to market its technology in a country with weak IPR laws, then there are other preventative measures. For example, easily self-reproducing plants could become available in major markets throughout Africa. The seed based company who is aware of this potential problem could counter the problem by licensing the product to private estates or selling the seed at a low price to eliminate any incentives (Lesser, 1992). The second case would probably cause a wider distribution and help many small farmers. The first case however, would only benefit the larger farmers who most likely do not need much external assistance.

Transfer. The transfer of technology can be difficult in developing countries. The availability and quality of inputs, experienced labor, and the necessary infrastructure cannot be assumed to be adequate. The productivity of technology usually declines as one goes from industrialized to developing countries. There needs to be a local technology effort (i.e. government support) for efficient technology transfer (Stewart, 1990).

Distribution. The actual transportation of the inputs can deter the transfer of technology. The transportation of agricultural produce and inputs varies from motor vehicles to dragging of goods by oxen. During the rainy season however, some roads are nearly impassable in many parts of SSA (Kiriro and Juma, 1991). For example, it would be nearly impossible to replace hoe's or animal traction with tractors in the Bungoma area of Kenya during the rainy season.[6]

Once the technology begins to flow there are still major constraints with distributing the seeds, fertilizer, vaccines, and tractors to name a few inputs. The route that most inputs will most likely be directed is through South Africa northward. However, the best route(s) for central Africa is unclear. The logistics of distribution must be worked out prior to a large commercialization effort is to take place.

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[6] It is estimated that there are 100 tractors and 12,000 ploughs in this area. Only 15% of the farmers relied on the tractors to prepare the land (75% used hoes) (Kiriro and Juma, 1991).

ABSP example. USAID is already involved in a project to assist in the transfer of technology to developing countries by educating certain countries about IPR. The objective of the Agricultural Biotechnology for Sustainable Productivity (ABSP) project is to enhance the U.S.'s private sector and developing country's institutional capacity for the use and management of agricultural biotechnology research in producing environmentally compatible and improved germplasm through collaboration and exchange with developing country scientists. The four countries involved with this project are Costa Rica, Egypt, Indonesia, and Kenya. The project identifies crops in each country that would benefit U.S. firms and the developing country.

The uniqueness of this project is that it links product-oriented research with policy analysis of intellectual property to ensure that the product is commercialized. Under this project, workshops on intellectual property rights and patent issues related to materials used in and generated by biotechnology projects were held. In addition, further training was offered through the form of seven internships at Stanford Law School where the interns were: encouraged to assess their respective current IP structures, provided with literature and expertise regarding IPR in both the public and private sectors, and developed case studies on ways to collaborate with industrialized countries (USAID/EG/AFS, 1994).

Due to the involvement of research firms, USAID, through the use of IPR consultants, drafted contracts between the research firm and the country so any existing or future patents would be protected under this agreement. With that type of protection, companies such as ICI Seeds, Inc. and Monsanto Chemical Co., were willing to participate. These types of innovative approaches are required to diffuse technology until the SSA countries IP laws are harmonized.

Commercialization

Assuming that the funding level for SSA will continue to decline, these countries will have to pursue indigenous sources of funding. The marketing of regional and international technology is probably their best option. The commercialization of technology is an important factor that should increase: the adoption of new technology, output, regional and international trade, and economic growth. In addition, these technologies may have the positive effect of decreasing environmental degradation by the use of efficient production methods. However, before commercialization can take place, the proper IP laws must be implemented. Multi-national firms and local African firms are unwilling to invest in research in sub-Saharan Africa for two reasons: weak intellectual property rights and the market size or potential. The down side to commercialization could be increased unemployment, and the dependency of developing countries on industrialized countries. This potential problem can be overcome with encouraging the demand side of the economy and making the patenting process more accessible to residents of SSA.[7]

[7]Setup a group similar to the British Technology Group (BTG) for SSA.

Regardless of the potential negative effects of stronger IP laws, it is evident that commercialization is mandatory. The forces from the rapid rise in world trade, and the growth in technology development coupled with the relatively cheap labor and resources in developing countries it is essential that the laws be reinforced (Boone and Mathieson, 1990). These countries will have to utilize indigenous resources including human capital if they are to participate in the current and future technology boom.

IPR enforcement. Most developing countries are not adequately informed about the rapid changes in IP laws in industrialized countries. They have limited capacity to interpret and enforce laws that relate to biotech innovations. In the U.S., biotech patent examiners are typically Ph.D. microbiologists, anything less risks granting to broad or narrow a patent. Therefore, the patent office requires well trained examiners with good technical support. Most SSA countries have too few Ph.D. scientists trained in this area to support national research interests and to complete adequate patent searches.

One solution to the problem of limited human capital is to use a regional system. The searches and examination services should be centralized, but the patents should be national. The granting of national patents allows the patent litigation to take place in the national courts. This gives the national governments the final decision and hence protects national sovereignty (Lesser and Coffman, 1991).

Commercialization of African research. Once the SSA countries start exporting their technology regionally and internationally, then the real problems will begin. There are several problems that must be worked out prior to attempting to commercialize technology in SSA.

- For example, which items should be patented, and are they public or private?

- Agricultural products are cumulative in terms of patents. One country or firm's R&D endeavors becomes the building block for another firm's activity. The legalities could become entangled.

- If the firm that receives government support sells its technology, will the national government reinvest those revenues or siphon them off for other projects? The innovative scientists and firms must be rewarded for their creativeness. Otherwise there are no incentives to be creative or to remain in the firm.

- If all of the research is dedicated to commercialization, there will probably be little done on the peasant or small farmer problems. In addition, as the SSA countries become more advanced, it is a possibility that there will be less demand for farm labor.

- If the germplasm is from multiple sites, should the community/region/nation be compensated? Ownership is not always clearly defined in some cultures or countries.

- How will the regional research institutions reinvest in their own research as well as financially support the representative governmental bodies?

Agricultural policy. The IP laws are extremely important in terms of attracting R&D type industries to do business in Africa. The other policies that may need to be adjusted are the national agricultural policies. Policies that will inhibit (price floors, subsidies, etc.) the commercialization of agricultural products must be reexamined. The incentives to the R&D firms to locate in SSA must be based on free market principles.

Learning from the U.S. experience

There are four ways to patent plant matter in the U.S. However there are loopholes in which the seed industry loses millions of dollars yearly. A synopsis of the 1991 study by Knudson and Hansen described below summarizes the situation in the U.S. with respect to IPR and the Seed Industry.

Plant patent act. The U.S. has protected property rights of plant scientists since 1930 when the Plant Patent (PP) Act was passed. This act protects all asexually reproducing crops.[8] Only the PP holder is allowed to asexually reproduce, sell, or use the plant for 17 years from the date of issuance of the patent. The disadvantage of this law is that anyone can replicate the plant via seed or sexually. Therefore, the patent holder loses potential income from their invention.

Plant variety protection patent act. The second IP law concerning plants was passed in 1970, the Plant Variety Protection Act (PVPA). The PVPA protects sexually reproducing pure line varieties.[9] These varieties are protected for 18 years (adjusted to match UPOV laws) starting from the date the breeder gets a certificate from the U.S. Department of Agriculture. There are two exemptions which are actually disadvantages of using PVPA for protection. The PVPA allows researchers free access to the protected seeds, and farmers are allowed to replant or sell as seed 49 percent of their harvest under the crop exemption rule (Cooper, 1991).

A well known case concerning PVPA laws was Asgrow Seed Co. versus Kunkle Seed Co., Inc. In this case a federal court ruled that the defendant could sell seed from a protected soybean variety because less than 50 percent of his income came from the sale of seed. The problem is that the defendant had sold 1.42 million pounds of seed (U.S. congress, Office of Technology Assessment, 1989).

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[8]Asexual reproduction is accomplished using the techniques of grafting, budding, cutting, or layering.

[9]Pure line varieties are the result of four to nine generations of self fertilization (offspring from the same pure line variety are genetically identical to their parents).

Utility patent. The most recent IP law to protect plants is the Utility Patent (UP) law. UP's were extended to sexually and asexually reproduced plants in 1980. The plants are protected for 17 years after the patent is issued from the Patent and Trademark Office. The disadvantages of this kind of protection is that it requires: full disclosure of the technology; patented material must be stored in a depository for 35 years, protection only begins after the UP is granted, and the filing and issue fees are higher than PPA and PVPA fees.

Trade secrecy. Trade secrecy has always been available to companies as a means of protecting innovations. However, this method is only relevant if the technology is not apparent in the result. This method is most notoriously used to protect hybrids, especially corn hybrids.

U.S. preferences by organization. The Office of Technology Assessment surveyed 39 biotechnology and seed companies, nurseries, and universities about how they felt about IPR laws. Biotechnology firms usually preferred UP's to PP's and PVPA's because the UP's have fewer exemptions and can be more broadly applied. Firms that were not affiliated with a chemical or pharmaceutical company preferred PVPA's over UP's because UP's have no research exemption. These firms want to make the germplasm available for research which could be done similar to the compulsory license setup.[10] Universities were more concerned with having access to the germplasm also.

In summary, the U.S. has several IPR laws that protect plant breeders. However, there are still several loopholes in which the plant breeders lose critical revenue that could be reinvested in research or simply used to reward the efforts of the innovator. This problem is not unique to the U.S. and has direct implications for sub-Saharan Africa.

Suggestions to donor agencies

The following list is a suggested guide on what to investigate concerning IPR in sub-Saharan Africa to encourage the transfer of and the commercialization of technology. This list emanates from the literature review as well as from the experience of individuals involved with those areas. The objectives of this list are to:

- determine the best way to encourage residents of SSA to become familiar with IP laws,
- strengthen IP laws to encourage R&D firms to locate in SSA, and
- expedite the process to file and receive patents, trademarks, and copyrights.

[10]Compulsory licenses are granted for the use of patented plants or plant parts to anyone who applies for the license.

The specific recommendations are:

1. Support and encourage the regional IP institutions.

2. Encourage independent countries to join the regional IP organizations.

3. Conduct a benefit—cost analysis on specific SSA countries. Explore Perrin's (1991) and other approaches to determining in each country the likelihood that Developing countries will be net gainers from adopting stronger IP laws.

4. Interview and have policy dialogue with regional firms, country officials, and researchers.

5. Interview executives and patent attorneys in multinational firms concerning IP protection, and the transfer of agricultural technology.

6. Examine UPOV, Zimbabwe's, ARIPO's, and OAPI's laws concerning harmonization.

7. Assist in training and technical assistance of staff at the regional IP organizations.

8. Develop a table that lists imports and exports of IPR sensitive goods for SSA countries.

Conclusions

SSA will have difficulty in commercializing agricultural technology until their laws are strengthened and enforced. The efforts of the donor agencies to encourage IPR in SSA should include as their objectives to: determine the best way to encourage residents of SSA to become familiar with IP laws, promote the strengthening of IP laws to encourage R&D firms to locate in SSA, and expedite the process to file and receive patents, trademarks, and copyrights. If these objectives are addressed, the delicate balance between economic growth and international trade may be satisfied.

This study of 15 SSA countries indicates that the residents are familiar only with the trademark IP laws. Patenting and filing industrial designs must be encouraged in the residents of SSA to promote indigenous innovations. This may be a factor for educating the people about the options of protecting their inventions or reducing the costs to attain a patent. Presently, these inventors may be using trade secrecy as their method of protection.

Research and development firms are not willing to locate in any developing country until their IP laws are in place and enforced. Once the laws are in place, the promotion of the market potential will be needed to ensure that R&D firms locate in SSA rather than another region of the world.

Lastly, the process for receiving patents could be enhanced by developing a firm similar to the British Technology Group for sub-Saharan Africa. This firm would initially search the various countries for marketable products and assist in obtaining the patent, trademark, etc. for the individual or company, and market the product for a specified percentage.

Bibliography

Boone, P.S., and J.A. Mathieson, "Intellectual Property Rights: Assessment of Current Policies and Practices, and Options for A.I.D. Initiatives," Washington, D.C., USAID Bureau for Program and Policy Coordination, December 1990.

Cooper, I.P., Biotechnology & the Law, Clark Boardman Co., New York, NY, Vol. 2, 1991.

Frischtak, C.R., "Harmonization Versus Differentiation in Intellectual Property Rights Regimes." In Global Dimensions of Intellectual Property Rights, In Science and Technology, eds. Wallerstein, Mogee, and Schoen, National Academy Press, Washington, D.C., 1993.

Horbulyk, T.M., "Intellectual Property Rights and Technological Innovation in Agriculture," Techno logical Forecasting and Social Change, 43(1993): pp. 259-270.

Juma, C., The Gene Hunters : Biotechnology and the Scramble for Seeds, Princeton, N.J., Princeton University Press, 1989.

Juma, C.and Ojwang, Innovation and Sovereignty: the Patent Debate in African Development, Nairobi, Kenya : African Centre for Technology Studies, 1989.

Kiriro, A. and C. Juma, "Managing Biological Diversity in Kenya." In Gaining Ground: Institutional Innovations in Land-use Management in Kenya, eds. Persley, G. J., Nairobi, Kenya: Acts Press, African Centre for Technology Studies, 1991.

Knudson, M, and L. Hansen, "Intellectual Property Rights and the Private Seed Industry", USDA/ERS Agricultural Economic Report no. 654, November, 1991.

Lesser, W.H. and W.R. Coffman, "Regionalizing Patent Offices: A Developing Country Approach for Agrobiotechnology", Unpublished, 1993.

Lesser, W.H., "Intellectual Property Rights in sub-Saharan Africa: An Evaluation of Cause and Effect for Agricultural Technologies," USAID, December, 1992.

Lesser, W.H., Equitable Patent Protection in the Developing World, Issues & Approaches, Eubios Ethics Institute, Christchurch Tsukuba, New Zealand, 1991.

Mansfield, E., "Unauthorized Use of Intellectual Property: Effects on Investment, Technology Transfer, and Innovation." In Global Dimensions of Intellectual Property Rights, In Science and Technology, eds. Wallerstein, Mogee, and Schoen, National Academy Press, Washington, D.C., 1993.

Maskus, K.E., "Intellectual Property Rights and the Uruguay Round," Federal Reserve Bank of Kansas Economic Review, 78(1993): pp. 11-28.

Meltzer, M., "Telephone Conversation," 9/19/1994.

Perrin, R.K., "Intellectual Property Rights in Agricultural Developmentt," Airlie House Conference, Unpublished, October, 1991.

Persley, G. J., Biosafety : The Safe Application of Biotechnology in Agriculture and the Environment, The Hague, The Netherlands: International Service for National Agricultural Research, 1992.

Persley, G. J., Gaining Ground: Institutional Innovations in Land-Use Management in Kenya, Nairobi, Kenya : Acts Press, African Centre for Technology Studies, 1991.

Sherwood, R.M., "Why a Uniform Intellectual Property System Makes Sense for the World." In Global Dimensions of Intellectual Property Rights, In Science and Technology, eds. Wallerstein, Mogee, and Schoen, National Academy Press, Washington, D.C., 1993.

World Intellectual Property Organization (WIPO), Geneva, Switzerland, "Telephone Conversations," 8/18/1994;
Mr. Andrea Heitz, Director of UPOV
Mr. John Hawkins, Patent Cooperation Treaty Division
Ms. Simpson, Statistical Department

World Intellectual Property Organization , The Situation of Industrial Property in the Countries of Africa, Geneva, Switzerland, International Bureau of WIPO, 1987.

UNCTAD Secretariat, "Intellectual Property Rights in a Changing Economic and Technological Environment." In Innovation and Sovereignty: the Patent Debate in African Development, by C. Juma, Nairobi, Kenya : African Centre for Technology Studies, 1989.

U.S. Congress, Office of Technology Assessment, New Developments in Biotechnology, Patenting Life, Special Report, OTA-BA-370, April, 1989.

Table 1. Patents Filed and Granted by and to Residents and Non-Residents in Kenya, Zimbabwe, and OAPI.

	Kenya Patents				**Zimbabwe** Patents				**OAPI** Patents			
	Filed		Granted		Filed		Granted		Filed		Granted	
Year	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non-Resi-dent
1980	0	96	0	97	39	281	24	194	*	*	*	*
1981	0	75	0	75	35	274	5	274	*	*	*	*
1982	0	76	0	76	41	230	19	255	9	290	2	182
1983	0	100	0	100	40	237	16	246	17	268	12	392
1984	0	122	0	122	34	191	17	170	21	258	26	199
1985	0	107	0	98	41	209	2	211	19	641	14	284
1986	0	100	0	100	*	*	*	*	*	*	*	*
1987	*	129	*	113	46	217	32	214	30	1030	*	225
1988	1	89	1	75	45	171	21	193	38	1484	35	239
1989	*	107	*	97	43	176	19	168	1	1805	*	*
1990	*	68	*	38	46	214	14	160	13	3302	7	53
1991	8	123	1	46	71	199	22	200	32	4431	17	133
1992	*	110	1	57	49	253	9	185	23	6079	13	379

* Represent missing data.
Source: World Intellectual Property Organization Industrial Property Statistics Report, various years.

Table 2. Trademarks Filed and Granted by and to Residents and Non-Residents in Kenya, Zimbabwe, and OAPI.

	Kenya				Zimbabwe				OAPI			
	Trademarks				Trademarks				Trademarks			
	Applications		Granted		Applications		Granted		Applications		Granted	
Year	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non-Resi-dent
1980	565	778	443	747	274	1177	192	589	*	*	*	*
1981	570	706	495	610	177	931	132	760	*	*	*	*
1982	457	778	506	804	189	760	128	838	69	1143	*	*
1983	487	506	404	649	118	546	132	619	78	740	*	*
1984	452	522	350	520	151	580	86	606	61	774	*	*
1985	613	566	393	431	*	*	*	*	*	*	*	*
1986	583	579	*	*	*	*	*	*	*	*	*	*
1987	497	473	399	455	269	491	216	468	81	809	*	*
1988	356	509	218	393	286	546	200	390	72	705	*	*
1989	350	582	249	378	321	744	272	527	148	745	*	*
1990	*	*	*	*	372	735	171	495	95	805	*	*
1991	210	502	193	315	425	830	233	658	73	740	*	*
1992	*	*	*	*	303	955	279	771	88	1027	*	*

* Represent missing data.
Source: World Intellectual Property Organization Industrial Property Statistics Report, various years.

Table 3. Industrial Design Applications and Granted by and to Residents and Non-Residents in Kenya, Zimbabwe, and OAPI.

	Kenya				Zimbabwe				OAPI			
	Industrial Design				Industrial Design				Industrial Design			
	Applications		Granted		Applications		Granted		Applications		Granted	
Year	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non Resi-dent	Resi-dent	Non-Resi-dent	Resi-dent	Non-Resi-dent
1980	*	*	*	*	6	11	5	8	*	*	*	*
1981	*	*	*	*	7	14	10	17	*	*	*	*
1982	*	*	*	*	8	15	5	9	10	66	*	*
1983	*	*	*	*	4	6	8	6	9	30	*	*
1984	*	*	*	*	3	20	2	14	25	21	*	*
1985	*	*	*	*	*	*	*	*	*	*	*	*
1986	*	*	*	*	*	*	*	*	*	*	*	*
1987	*	*	*	*	9	18	10	16	30	9	*	*
1988	*	*	*	*	10	7	8	6	66	4	35	4
1989	*	8	*	*	3	25	4	10	42	8	*	*
1990	*	*	*	*	2	20	2	8	21	8	*	*
1991	*	1	*	1	4	14	*	7	22	7	*	*
1992	*	*	*	1	13	17	7	21	29	5	13	5

* Represent missing data or no report.
Source: World Intellectual Property Organization Industrial Property Statistics Report, various years.

Table 4. Percentage of Major U.S. Firms in Six Industries Where Strength or Weakness of Intellectual Property Rights Reportedly Has a Strong Effect on Whether Direct Investment Will be Made.

	Type of Investment					
Industry[a]	Sales and Distribution Outlets	Rudimentary Production and Assembly Facilities	Facilities to Manufacture Components	Facilities to Manufacture Complete Products	Research and Development Facilities	Mean
Chemicals[b]	19	46	71	87	100	65
Transportation equipment	17	17	33	33	80	36
Electrical equipment	15	40	57	74	80	53
Food	29	29	25	43	60	37
Metals	20	40	50	50	80	48
Machinery	23	23	50	65	77	48
Mean	20	32	48	59	80	48

[a]The number of firms in the sample in each industry is chemicals, 16; transportation equipment, 6; electrical equipment, 35; food, 8; metals, 5; machinery, 24. However, not all firms in the sample responded to all questions.

[b]The chemical industry includes pharmaceutical.

Source: Reproduction of Mansfield (1993) Table 5-1.

Fruits and vegetables position paper

by

Jack Ross

Executive summary

This position paper for fruits and vegetables for sub-Saharan Africa will be used to assist in the design of a project called Sustainable African Agricultural Technology Systems (SAATS) Initiative. SAATS is part of a large project called Policy, Analysis, Research, and Technical Support (PARTS). The overall goal is to help USAID contribute to sustainable increases in African agricultural productivity through more effective development strategies, policies, programs and projects in the agricultural and natural resources sector. These increases in productivity should show in many ways from increased production of crops, greater profits in agribusinesses, more jobs, more income to the workers, lower food costs for staple foods, increased efficiencies in producing food and conservation of natural resources.

Key project clients include: Africans and African public and private organizations, USAID Missions, REDSOs, the African Bureau, other USAID/W offices, nongovernmental organizations, and other donors.

The major mandate of the overall project is to support the clients mentioned above to improve the effectiveness of African institutions to alleviate the slow growth in the agricultural sector productivity caused by (1) inefficient marketing systems and weak support services for agribusinesses, (2) low utilization of high yielding, profitable and sustainable technologies, and (3) degradation of the natural resource base.

The stakes in this effort are high, both for potential growth of African economies and for the well-being of millions of people who depend on agriculture for their lives and livelihood.

The general philosophy of the SAATS Initiative is to be demand-driven and/or market-driven. Future activities will concentrate in four areas (1) research (2) strategic planning (3) commercialization and dissemination of technology and (4) technology system policy reform. Because of the market-driven aspect of the project, this position paper for fruits and vegetables tends to deal with obtaining technology and adopting or adapting it into actual commercial use by agribusinesses. From the viewpoint of the agribusinesses, the goal is to produce food products and market them to make a profit.

Three sizes of agribusinesses must be considered:

(1) Small-scale with only a few workers in a rural area.
(2) Medium-scale for a larger urban area.
(3) Large-scale including multi-nationals geared to global markets.

The constraints faced by the SAATS Initiative and fruits and vegetables in Africa are numerous and apply to many disciplines much the same as in most developing countries. They are listed as follows:

(1) Social and cultural
(2) Government policy
(3) Teaching and research institutions
(4) Grading and inspection of product
(5) Packaging
(6) Cooling of product
(7) Transport
(8) Handling such as traffic flow or crowded markets
(9) Processing
(10) Market intermediaries such as wholesalers
(11) Market information
(12) Consumer related and
(13) Export related.

Because the constraints are so varied (policy, culture, research, teaching, technology, private sector, public sector, finance, communications, transport) and involve many different disciplines, it is recommended that multidiscipline studies be included in the future to help identify the needs of agribusinesses which can be supplied through the research effort.

Personnel of the public sector must be educated and guided in their efforts to assist private business. Public sector people need to know more about the operation of private businesses in order to help them. Seminars, short courses and workshops attended by a mix of public and private sector people are recommended so problems and ideas for solutions can be exchanged freely. It is not adequate to assume that this exchange of problems and ideas will occur without a specific program to force the exchange. Mississippi State University has a good program of this type for working with agribusinesses.

In order for agribusinesses to market their products efficiently, it is necessary to have a production base with sufficient capacity to fill fairly large orders from customers. It is recommended that agribusinesses, including farmers, form nonprofit marketing cooperatives or associations. A marketing cooperative can consolidate the production of small producers to create an efficient marketing system, particularly for export marketing.

Of all the problems faced by African agribusinesses and farmers, money probably is at the top of the list. Seldom do they have enough money or credit for operating expenses and capital expenditures. Next on the list of problems often is water which is critical for irrigation, processing and consumption by humans and animals. These two items may not be on the list of responsibilities for the SAATS initiative, but if they are not considered, increased production and efficiencies will be severely retarded.

Fruit and vegetable position paper

The scope of work includes the following general information:

The goal of the Policy, Analysis, Research and Technical Support (PARTS) Project is to contribute to sustainable increases in African agricultural productivity through more effective development strategies, policies, programs and projects in the agricultural and natural resources sector. The project supports clients to increase their capacity and efficiency necessary to achieve project objectives through increased utilization and influence of information and analysis in the agricultural and natural resources sector in sub-Saharan Africa. Key project clients include: Africans and African public and private organizations, USAID Missions, REDSOS, the Africa Bureau, other USAID/W offices, nongovernmental organizations, and other donors.

The major mandate of the project is to support the clients mentioned above to improve the effectiveness of African institutions to alleviate the slow growth in agricultural sector productivity caused by (1) inefficient marketing systems and weak support services for agribusinesses, (2) low utilization of high yielding, profitable and sustainable technologies, and (3) degradation of the natural resource base.

The Sustainable African Agricultural Technology Systems (SAATS) initiative background

The analytical work supported by the PARTS Project has caused new awareness of agriculture's role in economic development and the key roles that technology development and transfer play in future needs. Africa has some unique requirements in agricultural technology development and transfer (TDT) that other continents, regions, and time periods do not have. The stakes in this effort are high, both for potential growth of African economies and for the well-being of millions of people who depend on agriculture for their lives and livelihood. Productivity increases are vital to agricultural growth, which is in turn critical to economic development in Africa.

Recent evidence shows that research and TDT are able to contribute significantly even in less than perfect conditions. Technologies exist that have made significant people-level impacts in many countries. More are under development. The biggest challenge now is to create sustainable and effective research systems that can catalyze agricultural transformation in this century and the next.

African agricultural institutions face a number of unique challenges and constraints that point toward regional approaches. While there is considerable unevenness across countries, many agricultural research systems (NARS) in Africa are relatively small. The counties they serve often have diverse production patterns, unlike countries in Asia where a single crop (i.e., rice) helps focus research priorities. African resources are limited. National systems cannot achieve excellence in all areas. In this environment, establishing priorities is important.

An important feature of Africa is that, for the most part, their agricultural economies are in an earlier stage of development than most counties in Asia or Latin America; and perhaps at an earlier stage than those countries were when the Asian and Latin American research systems were established. Agricultural transformation is just beginning in many African countries. This creates a unique opportunity of integrating the research systems into the initial stages of agricultural transformation in a way that contributes directly to economic growth and improved people-level impact.

Many African research institutions were developed at a time when governmental control of the economy was the dominate mode. They were developed during periods when political pluralism was limited, and agricultural interests—whether at the production or the processing level—were poorly organized and ill-defined. These institutions now face economic reform that reduces government resources and increases the role of market-driven funding available to support agricultural research decreases. Thus, the institutional management put in place before reforms needs to be realigned with the realities of adjustment—increased marketing orientation and financial limitations. This is happening in other parts of the world as well, but the challenge is more dramatic in Africa. The need for change is very urgent.

The key challenge that the SAATS Initiative will address is to assist African countries improve the welfare of the next generation of Africans through sustained increases in economic growth and improved environment. Within the next three decades, food needs in Africa will triple while, during the same period, per capita arable land is projected to decline to less than half of the current levels. It is estimated that it will require a growth rate of 4 percent per annum in agricultural production in Africa to achieve sustainable economic growth. To meet this challenge, Africa has to realize sustained increase in agricultural productivity while ensuring the protection of the natural resource base. This needs a two-stage process: The first is the development of sustainable technology systems that integrate agriculture, livestock, natural resources and the environment. The second is to enhance the productivity of the agricultural sector through the integration of technologies, markets and policies. Developing effective, sustainable African agricultural technology systems in the context of limited integration among interrelated but complex sub-systems is a major challenge for Africans, the donors and the international research community.

The SAATS Initiative has numerous responsibilities. Some should be mentioned here. One is to be more demand-driven, thereby enabling support research systems to respond to market demands with profitable and sustainable technologies that support economic growth and environmental sustainability. Better links with input suppliers, processors, marketing agents, consumers and policy makers would make researchers more capable of addressing transfer and adoption issues. Another responsibility is to make technology development and transfer more result-oriented so that researchers and technology users have incentives and mechanisms to transfer, transform, commercialize and use profitable and sustainable technologies. It should encourage development of effective coalitions among public-private sector agents to effectively transfer, commercialize, and utilize technology.

Expected outcome of the SAATS initiative

SAATS will operate at the regional level and will lead to outputs at the national, enterprise and household levels. Indicators of progress and people level impact include the following:

(1) an improving and enabling environment and strengthened research capacity for national and regional systems:
(2) an increased efficiency in the development and transfer of technology among and by national and regional technology systems:
(3) an increased use of profitable and sustainable technology among producers, processors, and marketing agents involved in selected food systems:
(4) lower food prices for staple foods that will, in particular, benefit poor consumers:
(5) release of on-farm labor to participate in high value-added agricultural and nonagricultural activities:
(6) increased incomes and employment from profitable agricultural enterprises for which technology is developed and used;
(7) an enhanced resource base for selected production systems:
(8) a protected environment and natural resource base.

The proposed SAATS activities are grouped into four areas of concentration:

- Collaborative eco-regional research
- Strategic planning (priority setting, impact assessment, socio-economic)
- Commercialization and dissemination of technology
- Technology system policy reform

At the heart of the future efforts is the challenge to avoid the trap of using hindsight to redesign or fine-tune the research institutions we wish we had in the 1970s and 80s. The world is changing in fundamental ways and there are new challenges facing African agriculture.

Situational analysis

What are the needs of agribusiness now and in the future?

The goals and needs of men and women involved in agriculture and agribusiness can be stated very simply. The people want to produce a commodity that can be readily sold to make a profit for themselves. This profit should be adequate to provide a reasonable living for the people involved, and also to provide adequate capital to sustain their agricultural and business operations in the future. These goals and needs can be described and embellished in many ways, but the simple concept of making a profit for the present and in the future quickly gets to the heart of what people involved in agriculture want and need. This method of describing the goals and needs is used because it is so easy to forget this simple concept as plans are made to provide indirect assistance to agriculture by building infrastructure facilities or new agricultural research stations. Often this indirect assistance doesn't really get around to directly helping the people on the farm or in a processing plant who need immediate and tangible assistance in the struggle to make a profit. The indirect assistance such as paved roads, telephones, electricity, and running water is very important and valuable and should not be neglected. However, often that doesn't provide the immediate assistance needed to make a profit today and tomorrow.

Many people in Africa are attempting to find work and earn a living in nonagricultural industries. Women in particular are forming small cooperatives to create jobs such as sewing clothes, making jewelry from ostrich egg shells, or making souvenirs from discarded tin cans for the tourist trade. However, for millions of Africans, there simply are no jobs available and agriculture is the only choice for them to work and provide for themselves. This was pointed out to the author in July 1994 during a visit to a small cooperative near Capetown, South Africa. This cooperative consisted of eight African women who made rugs from used cloth. They were having severe financial problems because of the lack of sales. When asked what they would do if they could not continue with the cooperative, they answered that they would have to go into farming to earn a living or they could just do nothing.

This same situation was observed in Botswana, Zimbabwe, and Zambia where various commodities were produced including fruits and vegetables. The small agricultural cooperatives, composed mostly of seven to ten women, had some problems with production but their biggest problem was in marketing. Usually there was no sales outlet other than roadside stands. Profits were very small. Some countries, such as South Africa, do have large and well-managed farms that produce fruits and vegetables, pack them in boxes for local and export markets, and realize satisfactory profits. However, there are millions of people involved in agriculture who need assistance in modern technologies to operate their business satisfactorily.

The SAATS Initiative recognizes the above problems. The Initiative also recognizes that there are additional problems which must be addressed. One way to summarize some of these problems is to repeat the fact from the Scope of Work that in three decades, food needs in

Africa will triple while, during the same period, per capita arable land is projected to decline to less than half of the current levels. The key challenge is to improve the welfare of the next generation of Africans through sustained increases in economic growth and improved environment. These challenges must be met while, at the same time, natural resources are protected and used wisely. The Initiative is looking at the long-term solutions as well as short-term. Both are important.

How can the needed research information be obtained?

In the future, the diverse regions and nations of Africa will be able to generate part of the research information and technology needed for the growth of the fruit and vegetable industry. Considerable information that is pertinent and applicable already exists either in Africa or in other parts of the world. Before moving too quickly into the reshaping of existing research facilities and programs in Africa, the supply of existing and applicable technology should be evaluated worldwide. It makes good sense to use existing technologies regardless of the location or source so that the research facilities in Africa then can concentrate on the localized technologies and needs that apply to their clients. These clients include: Africans and African public and private organizations, USAID Missions, REDSOS, the African Bureau, other USAID/W offices, nongovernmental organizations, and other donors.

For Africa, public sector research facilities have produced considerable technology that is helpful in the fruit and vegetable industry. The need for postharvest handling technology for processing and exporting has increased in recent years. Because this need often is related to international exports, the most common source of information has been importers in Europe who tell African exporters what they want and how they want it prepared. Another source of information has been salesmen for suppliers (sometimes local, sometimes foreign) who have a vested interest in what technology is used. Packaging suppliers fall into the latter category.

In 1991, there was a major project to consider a Global Plan for an AID/R&D/AGR program called Postharvest Collaborative Agribusiness Support Program (CASP). This project was done by Winrock International Institute for Agricultural Development, Morrilton, Arkansas in association with Development Assistance Corporation, Washington D.C. It was prepared under A.I.D. Contract PDC-1406-I-00-32-00.

The purpose of the CASP project was to prepare a comprehensive program that would provide USAID/R&D/AGR with guidance to the most appropriate field support and mix of research, technical assistance and training for worldwide postharvest agribusiness development with respect to eight food commodities that were considered the most important. These commodities were grains, legumes, perishables (fruits and vegetables), seeds, animal products, crop by-products (primarily animal feed), dairy products, and fish products. This program had inputs from fourteen senior agriculturists, four of them as a core team and the other ten as specialists in specific agricultural commodities. The CASP report has a wealth of information that is pertinent to Africa. For this SAATS report, only fruits and vegetables are considered.

For research institutions providing technology for fruits and vegetables, the question was asked about the relative importance of dependable funding, modern physical plant, willingness to take risks in meeting new needs, inflow of newly trained staff and openness to new problems to be researched.

Dependable funding and modern physical plant are at the top of the list. They are critical. The other features are important but they can be obtained if the first two items are in place. Openness to new problems to be researched is critical but that should fall into place if the frequent and open contacts between public and private sector are realized.

Most sustainable agribusinesses have characteristics that encourage flexibility and the ability to know what is happening in the production of their commodity and in the marketplace where their commodity is sold. Often this includes having a certain amount of "worldliness." Aggressive, well-trained management is the first step. A major prerequisite is availability of money with which to operate and provide facilities such as land, buildings, processing equipment, supplies, transportation, communication, and markets. Water of the proper purity is needed. If these things are available, an adequate production base is needed to provide sufficient product to fill customers' orders in a timely manner with the correct quality and quantity requested by the customer. Getting repeat orders for the products being produced is important in sustainable agribusinesses. This is another way of saying that good marketing practices are essential. Note that technology as such has not yet been mentioned. This is because the availability and use of technology is interwoven all through the business operations and practices.

Constant and ever-changing technology is used and is absolutely essential throughout agribusinesses. When all the above requirements are in place, then other considerations become important—the supply and skills of the labor force, business climate favorable to the private sector businesses, supplies, and many other "details." A successful sustainable agribusiness will have all the above characteristics. Management will be very knowledgeable and they will have many personal and business contacts throughout the private and public sectors in which they must operate. If their business has a problem, they know whom to contact for help. Similarly, a good thing for public sector organizations, such as research facilities, universities, and nongovernmental organizations to do is to cultivate their acquaintances and contacts assuring them of numerous contacts, both private and public sector, so they know what to do and whom to contact when they want to do something. The above dissertation is a bit lengthy but it includes the typical characteristics of a successful sustainable agribusiness.

As a private sector business person views the public sector, especially universities and research facilities, one of the most desired characteristics of "scientific" people is to be able to provide technology and information that is useful in managing businesses. Especially important are researchers and extension people who are practical, easily approachable, easily accessible, and appear to have a genuine interest in helping the private sector. They want to be able to pick up the telephone and call these people. What they do not want is someone who acts as though research work is the center of all knowledge and therefore is above the comprehension level of the private sector business man. Perhaps the best personal trait for a

researcher to have is an outgoing personality and the ability to communicate with the private sector people of all levels without giving the impression of talking down to them. This results in a free exchange of information and technology which is one of the big differences between slow growth and rapid growth nations. This appears to be the main thrust of the SAATS Initiative. That is good.

Developing, accessing and using technology is an important part of the SAATS Initiative. In the Scope of Work under Design Issues and Concerns, the means of handling technology is considered. The postharvest handling technology in fruits and vegetables is both voluminous and broad which means that it is unlikely that each African nation can or should develop all of &their own technology. A better choice is to import as much technology as possible, including postharvest technology, and adapt it to local conditions and then transfer it to the client or consumer who will use it in the pursuit of results in research or in conducting an agribusiness. In some situations it may be necessary to develop all the technology on the local or regional level but this usually is not the case. A good example of this is the work done by the Malaysian Agricultural Research and Development Institute (MARDI) in Kuala Lumpur, Malaysia. They use various sources of technology but primarily the data base of the ASEAN Food Handling Bureau (which just happens to be in Kuala Lumpur). MARDI adapts this technology to local conditions and then works with Malaysian businesses who actually use the information in their daily operations. Another example is the Asian Institute of Technology in Bangkok, Thailand. Much of their postharvest technology comes from the ASEAN Food Handling Bureau in Kuala Lumpur. AIT cooperates with local businesses to adapt and use the technology in their operations.

Existing technology can be used for fruits and vegetables in Africa for many postharvest handling problems. Numerous organizations around the world maintain a data base that is accessible at no cost or for a very small fee. For example, The Postharvest Institute for Perishables (PIP) at the University of Idaho has a Perishables Information Center (PIPIC) which has a collection of over 12,000 documents on postharvest topics. Bibliographic citation files are computerized for quick retrieval and sorting. Topic oriented bibliographies and microfiche/paper copies are available to any individual or organization on request. In addition to in-house searches, PIPIC can access national and international databases for postharvest information. To help increase worldwide access to postharvest information, PIPIC serves as a networking center for individuals and agencies around the world. To contact PIP, telephone (208) 885-3576 or fax (208) 885-3582. Harvey Neece is the Director, Judy Edmister is the Field Director. PIP provides short courses, seminars and workshops upon request for USAID Missions and cooperating countries. They maintain a computerized roster of experts who are available for short and long term assignments to developing countries.

PIP has joined forces from time to time with the Association of South East Asian Nations (ASEAN) Food Handling Bureau in Kuala Lumpur, Malaysia and also with the Inter-American Institute for Cooperation on Agriculture in Costa Rica. Thus, it has become part of a global network of international centers and national institutions concerned with postharvest handling of perishables including fruits and vegetables.

The Postharvest Institute for Perishables (PIP) was founded in 1980 at the University of Idaho in response to growing alarm over the high levels of food losses and market inefficiencies between harvest and consumption in developing countries. PIP's objectives are:

- Improve the nutritional status of people in developing countries by increasing the availability of fruits, vegetables, roots, tubers, nuts, oilseeds and spices through reduction of postharvest losses.

- Reduce costs and improve the quality of perishable commodities by improving/modifying postharvest handling, transportation, storage, packaging, and marketing systems.

- Encourage the development or improvement of processing and other industries associated with perishable crop commodities.

- Increase the incomes of small farmers and agribusinesses by improving the efficiency of marketing systems and reducing losses of food commodities in the marketing chain.

Fruit and vegetable crops to be considered for Africa

A listing of the possible crops that may be grown is important in discussing what is needed to produce them. Africa has many climatic conditions so the following list of possible crops includes tropical, semitropical and temperate crops.

1. Apples
2. Oranges
3. Grapefruits
4. Pomelos (Pummelos)
5. Limes
6. Peaches
7. Nectarines
8. Apricots
9. Mangos
10. Grapes
11. Papayas
12. Avacados
13. Bananas
14. Carombola (Starfruit)
15. Cashew Nuts
16. Green Coconuts
17. Ripe Coconuts
18. Durians
19. Guavas
20. Jackfruits
21. Jujube
22. Longans
23. Litchis
24. Mangosteens
25. Passionfruits
26. Pineapples
27. Rambutans
28. Sugar Apples
29. Sweet Tamarind
30. Watermelons
31. Strawberries
32. Eggplants
33. Okra
34. Gherkins
35. Garlic
36. Asparagus
37, Greengram
38. Cowpeas
39. Peanuts (Ground Nuts)
40. Zucchini (Courgette)
41. Sesame
42. Squash
43. Onions, Round
44. Onions, Green
45. Onions, Shallots
46. Root Chicory
47. Red Chillis (Capsicum)
48. Cabbage
49. Leafy Vegetables
50. Turnips

This is a sizeable list of fruits and vegetables. More can be added. Some of them are not important to Africa at the present time. However, all the items on this list are being produced in Asia and Latin America for local consumption or export to other countries. It seems reasonable that Africa will have a place for all of them in the future when one considers the varied climates and needs of Africa.

If these crops are to be grown in Africa, it is likely that varietal selection will have to be done by trial plantings. This may be on formal research stations or on private farms. This report assumes that the various research personnel working with these crops are familiar with the agronomic technologies and that they know best what needs to be done in Africa prior to harvesting. The selection of the crops that will be grown will be dictated by local conditions so no attempt is made here to justify why certain crops are selected. Other than using some market research or other data related to marketing and consumption, crop selection is more of a business decision or personal decision than a research function. Therefore, this report tends to deal with the technologies and needs of the fruit and vegetable industry from harvest onward.

Water is one of the critical needs through the production and processing cycles. This may be irrigation water, drinking water, or water used after harvest for processing. Much of Africa has wet seasons and dry seasons. Usually dry season means that rainfall is essentially zero. No rainfed assistance can be expected during the dry season to grow fruits and vegetables that need frequent watering. Even most tree fruits require irrigation during the dry season. Conversely, wet seasons can produce too much water and be a problem instead of creating good conditions for soil preparation, growing crops, and harvesting them. Therefore, some of the best fruits and vegetables can be produced during the dry season if irrigation water is available at the proper times.

The need for potable water is critical during processing. The world is becoming acutely aware of the problems involving chemicals and chemical residues in food. Sanitation must be carefully observed, particularly if the processed product, both fresh and preserved, is to be exported. In this report, processing includes preparing fruits and vegetables for the fresh market. It also includes the typical preserving techniques such as canning, freezing, drying, juicing, fermentation and pickling.

Sizes of agribusinesses in developing countries

The size of an agribusiness has a strong influence on what is needed in technology whether it involves land area, water, facilities, machinery, transportation, refrigeration or methods of marketing. The following three categories of size of an operation provide good guidelines (Paul Singh, "Planning a Collaborative Agribusiness Support Program on Postharvest Development: Process Engineering", 1991). The products may be sold as fresh, preserved, or both.

1. Small-scale enterprises which involve a few workers (often a single family) mostly located in rural areas. The activities are primarily limited to carrying out minimal processing mainly to stabilize a commodity and prepare it for marketing.

2. Medium-scale establishments are designed to meet the consumer needs for a larger region, most often the growing population in urban areas. In addition to primary processing, a number of secondary operations such as canning, freezing, drying, and extrusion are conducted to add value to the product.

3. Large-scale (including multi-nationals) enterprises are mostly geared to manufacturing foods for distribution on a national scale as well as export for sale in global markets. Often state-of-the-art equipment and processes are employed to manufacture high quality products.

Parastatals

There seems to be no reason to have Parastatals in the fruit and vegetable industry.

Potential worldwide market for fruits and vegetables

(Ronald Buscher, *Planning a Collaborative Agribusiness Support Program On Postharvest Development: Perishable Products,* 1991) Horticultural crops include the broad categories of fruits, vegetables, nuts, herbs, spices, flowers, ornamentals, and certain pharmaceuticals. Common factors making these crops perishable include high moisture content, large size, high rates of respiration, tender structure, and fragile nutrient, flavor and pigment components. In terms of importance, 1989 world production for commercial purposes was 590 million metric tons (mmt) for root crops, 434 mmt for vegetables and melons and 336 mmt for fruits of which Less Developed Countries (LDC) production was 39 percent, 36 percent and 55 percent or the respective totals. LDCs produce 90 percent of the world's spices. On a worldwide basis, horticultural crops provide 90 percent of vitamin C, 50 percent of vitamin A, 35 percent of vitamin B6, 25 percent of magnesium, and 20 percent each of iron, thiamine and niacin. A final factor making these commodities potentially profitable is that 50 percent of fruits and vegetables in developed countries receive some additional postharvest processing while in LDCs the proportion is less than 1 percent. The potentials for additional investment, employment, income generation, and trade are tremendous.

Constraints (general)

Africa has the typical constraints in fruits and vegetables that most developing countries have. The degree of importance of individual constraints to agribusinesses depends on the situation. Note that farming is considered to be an agribusiness just as much as operating a packing-house or processing plant for fruits and vegetables. One constraint that almost always is a factor in the success or failure of an agribusiness is the failure to provide a large enough

production base, particularly in medium- scale and large-scale enterprises. This constraint will be discussed later and tied in with organizing cooperatives that can provide a production base that is adequate to supply sufficient quantity and quality of fruits and vegetables to operate an agribusiness efficiently.

Constraints That Have an Effect on Fruits and Vegetable Agribusinesses: (Ronald Buscher, *Planning a Collaborative Agribusiness Support Program on Postharvest Development: Perishable Products,* 1991: also Jack Ross, K. Owusu-Sekyere, *Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Ghana: A Study of Postharvest Technology for Fruits and Vegetables*, 1992)

1. Social and cultural constraints

   - Lack of understanding of the role of women in postharvest fruit and vegetable activities, i.e., marketing.

   - Lack of understanding of household and cottage industries in processing fruits and vegetables, i.e., preservation, drying, fermentation.

   - Lack of understanding of impact on small farmers as fruit and vegetable production is directed toward export markets.

2. Government policy constraints

   - Unfavorable government regulations for export/import practices.

   - Taxes, fees, possibly bribes required for interregional hauling and trading. Countries in Africa are relatively small and crossings of borders are frequent.

3. Relevant institutions

   - Lack of institutions or underdeveloped teaching and research institutions such as:

     a. Inadequate facilities.

     b. Deficient technical assistance from public sector research and extension agencies.

     c. Absence of appropriate research and technical assistance from public institutions/agencies.

     d. Lack of training or experience in providing assistance in the private sector.

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e. Lack of knowledge of private sector practices and problems.

f. Lack of knowledge of adaptive research and training requirements to solve domestic problems and advance knowledge.

g. Lack of creative programs to solve problems of practical importance to the private sector.

h. Inexperience and lack of confidence with modern postharvest practices and instrumentation.

i. Lack of communication and transport (telephones and cars) to visit and work with potential clients in the private sector.

j. Lack of acceptance by the private sector due to unreliable and ineffective performance in the past.

k. Lack of capital for almost everything—programs, laboratories, instrumentation, transport, supplies.

5. Grading and inspection

- Lack of information/training on postharvest requirements for quality protection.
- Insufficient control of insects and sanitation.
- Inadequate inspection and quality assurance procedures for domestic and export products.
- Inability to issue phytosanitary certificates quickly to expedite export shipments.
- Inability to test for chemical residues in fresh and preserved products.

6. Packaging

- Lack of strength of corrugated boxes and containers.
- Lack of equipment to test strength of packaging.
- Lack of equipment to print good graphics on corrugated boxes.
- Containers and sacks filled with produce too heavy for proper handling.

7. Cooling

- Lack of appropriate cooling and cold storage facilities throughout the system.
- Lack of seaport and airport facilities for temporary storage and accumulation of products to be exported.
- Lack of cargo handling facilities and equipment at airports.

9. Transport

- Lack of adequate transportation (road, rail, sea, air)
- Transport in open-air vehicles resulting in heating, drying, water soaking with rain and microbial contamination.
- Lack of refrigerated transport.
- Multipurpose transportation used for produce, other commodities, animals and humans.

10. Other handling

- Lack of knowledge about handling of fruits and vegetables at all levels.
- Congested traffic flow in wholesale markets. Lack of unloading and distribution inlets and outlets.
- Crowded, unsanitary market conditions.
- Health hazards caused by food-borne toxins and disease-causing pathogens.

11. Processing

- Undeveloped management, technical and equipment maintenance skills.
- Undependable supplies of fruits and vegetables, insufficient quantity and quality.
- Inadequate quality assurance standards for producing reliable, uniform quality products.
- Ingredients and containers not domestically available.

- Lack of technical knowledge about the physical properties of tropical fruits and vegetables.

- Lack of food technology and processing pilot plants.

12. Market intermediaries

    - Transactions not based on grades and standards.

    - Farmer has no control over the prices from wholesalers.

    - Lack of incentives or awareness of benefits for improving wholesale market facilities and procedures.

13. Market information

    - Unreliable or lack of domestic and export market news and options for alternative market outlets.

    - Lack of knowledge of competitive market windows for individual perishable commodities or processed products.

14. Consumer demand

    - Limited choice of markets.

    - Dependence on local, seasonally available crops.

    - Public interest in purchasing processed products damaged by undependable quality.

    - Major fluctuations in prices.

    - Frequent (daily) acquisitions of perishable foods necessitated by lack of food storage facilities at the consumer level, i.e., refrigerators.

    - Lack of interest and knowledge in the household about preservation/processing procedures for extending storage life and securing a uniform supply of fruits and vegetables.

    - Fixed traditional consumption habits or beliefs that restrict utilization of new foods or food products.

- Domestic consumption of processed foods is limited and market potential of new products unknown.

15. Exports

- Small production bases unable to fill large orders with quality products.
- Lack of promotion of products.
- Insufficient consideration given to international quality standards.
- Lack of knowledge of export/import regulations.
- Containers, packaging and products below international standards.
- Unreliable air, sea, and land transport.
- Lack of knowledge of recipient countries' limitations on type, form, time or quantity of imported products.

Major constraints, prioritized

In general, the following prioritization is taken from The CASP Report by Winrock dated March, 1992. The author of this Position Paper for Africa was part of the Winrock core team for the CASP Project.

There are numerous constraints in less developed countries within each part of the postharvest chain proceeding from the producer to and including the consumer. Related to many of the constraints is the lack of favorable markets for the commodities produced and services performed. Perishables are generally higher valued than durable crops; however, perishables require more postharvest technical assistance and infrastructure development than durable crops to retard deterioration. Unfavorable markets are the major constraint to advancement of postharvest systems for perishables and associated development of agribusiness; thus, factors that limit market development become the limiting constraints. These limiting factors vary in importance depending on the commodity and country. Most often, major problems occur in identifying constraints that limit development of commodity systems, even though favorable markets have been identified. Therefore, integrated, multidisciplinary studies are necessary to identify constraints that suppress development of specific markets of perishables and their products. The failure of public research and training institutions in LDCs to effectively assist in solving problems for agribusiness development is primarily due to their failure to address relevant problems that, if solved, would have a major impact on reducing postharvest losses and facilitate market development. The public sector needs to know more about private sector business in order to help them.

A case in point is the pineapple industry in Ghana. (J. Ross and K. Owusu-Sekyere; Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Ghana: A Study of Postharvest Technology for Fruits and Vegetables, 1992). Pineapple growers want to sell their fresh pineapples in the domestic market and also in the export market in Europe. The problem is that the growers have only a few hectares of land which means their production of fresh pineapples is not enough to fill orders for export in a timely manner. The quantity and quality of fruit available from any one grower is not sufficient to fill export orders at the requested times demanded by importers in Europe. This results in incomplete or late orders and often includes inferior quality of fruit just to complete the requested quantity. This causes dissatisfied customers and the loss of repeat orders.

A good solution is to create a bigger production base so, at any given time, the supply of fresh pineapples will be sufficient to fill export orders at the desired delivery time with the quantity and quality of fruit requested by the customer. Forming marketing cooperatives or associations specifically to market the production of a group of producers, who alone are not big enough to market efficiently, can allow individual farmers to share in increased benefits and efficiencies from pooled efforts. Farmers, producers, or agribusinesses can form a marketing cooperative whose purpose is to market all the production of its members. The cooperative, a nonprofit organization, can provide a large production base from which producers can operate, find markets for their products and even set up a purchasing arm so they can pool their orders and purchasing power to get needed supplies (such as fertilizer, chemicals, cartons, cans) at the lowest possible cost.

Sunkist Growers, Inc. is typical of a very successful American marketing cooperative. Sunkist is the marketing arm worldwide for over 6,000 citrus growers and about 65 citrus-packing houses in California and Arizona. They also have a purchasing service to provide members with "economies of scale." Sunkist sales are in the order of 80 million cartons of fruit per year which translates to over one billion US dollars per year to the members of the cooperative. For Africa, marketing associations do not have to be big. Small cooperatives can fulfill the needs of many local or regional situations.

Studies show that in the most successful cases of the adoption of technology produced by research, there were effective links between commodity markets, input supplies (fertilizer, seed, agrochemicals, equipment), and credit. Credit usually is the item most frequently requested by agribusinesses in these cases. Partial success was possible where markets existed but input supplies were imperfect. Poorly functioning markets and unreliable input systems led uniformly to failures. Reviews of studies of technology produced by research and the adoption and adaption of that technology show that having a market for the end product is crucial. So, in line with having a demand-driven or market driven system, a market for the end product should be included in the plans at the outset. It is important that this market is described in simple language so the average agribusines person can understand it. Fancy terminology and buzz words that do not have easily understood meanings have no place in describing and discussing markets in the agribusiness world.

The research system should be geared toward responding quickly and effectively to market realities. Include more private agribusiness people who have a genuine monetary incentive to use the results of research to increase their profits.

There are two important phases that must be included in a research system designed to produce information useful to industry. The first is to decide what specific research work, based on industry needs, is to be done. The second is to get the research results and test them commercially. After the research results are available and ready for commercial testing, it is necessary to work with aggressive business entrepreneurs to test and use the results to prove that businesses can benefit by using the results produced by research. Note that, in the context of this paper, the research is intentionally designed so that a good portion of the results are quickly beneficial to industry. This goes along with the concept of research work being market driven. Included in this is the acceptance and use of the strong opinions of business people in private industry. It is necessary to choose these business people judiciously to be sure of getting correct and worthwhile opinions that represent industry fairly and without bias. Typical methods of exchanging ideas and opinions about proposed research subjects include seminars, workshops, and personal visits. Meetings of this type are used to give out research results and useful information as well as to solicit ideas for future research work. The University of California and many other organizations make extensive use of meetings for this purpose.

For example, in Ghana the public sector can cooperate with the private sector in technology development and rapid adoption by working with a producer-exporter of pineapple to make a trial export shipment to an importer in Europe. The key is to get the various interested parties acquainted and working together to make a jointly sponsored export shipment. The importer in Europe can assist by agreeing to provide information about the required price, quantity, quality, shipping dates, packaging, and other pertinent information important to his business. The private sector producer-exporter can provide the pineapples with the provision that he will be paid if the shipment is successful. A public sector researcher can work with all parties involved to provide the necessary technology—decay control chemicals, grade standards, shipping temperature, and handling techniques. A shipping agency can provide a refrigerated container or cargo space to make the shipment. Plant quarantine people can assist in helping follow the required rules and the issuing of a phytosanitary certificate. It is advisable for some or all of the participants to follow the test shipment to its destination in Europe to determine the results and to determine the degree of success and make plans for continuing shipments. In a cooperative effort like this, the participants become personally acquainted with each other and, if the shipment is a success, the contacts for subsequent shipments are already in place. If all the interested parties share the responsibilities and the cost of a test shipment, financial risks are minimal, technology has been put to immediate use, and business relations established for continuing in the future.

The implementation of the two phases described above is important. Usually these phases depend on the personal initiative and aggressiveness of only a few people in a research system. This is true in most successful research systems that have a reputation for producing

good useful results that are quickly available to agribusinesses in fruits and vegetables. For example, if one business person were to ask one of his peers whom to contact for some important postharvest information, he would probably be given the name and phone number of a specific person in a research organization appropriate for the subject. This person is chosen for his or her ability to produce good results and information, and also for the ability to help put those results into commercial practice.

One of the most difficult constraints of agribusiness in Africa is the lack of capital, both for operating funds and for capital expenditures. Funding of businesses is not part of the SAATS Initiative but is important to remember as researchers and technologists work with private entrepreneurs. The public sector can't be cooperative or productive if there isn't any capital for them to work with.

General recommendations

The SAATS Initiative appears to be right on target to produce assistance that is needed in Africa. The Scope of Work, background, recognized challenges, purpose, goal and the expected outcomes all are sensible and well thought out. The theme of helping agribusinesses (which includes farmers) achieve success and profitability is good because, if that is successful, the other needs such as increased agricultural and agribusiness production, increased job availability, and economic growth also will be successful. Peace is an indirect result of attaining the above goals. The dramatic change toward peace in South Africa since the April, 1994 election demonstrates the attitude change among black and colored people there. They think they now have an opportunity to have jobs and a reasonable scale of living in the future.

The recommendation is to proceed as planned with the SAATS Initiative.

Specific recommendations

Instead of going through the long list of constraints to examine each one, it seems adequate to say that all of them need to be addressed, although not immediately and not at the same time. The following recommendations relate to the constraints and include opinions and ideas relating to priorities and methods of attaining solutions to the more urgent constraint problems.

In the context of this paper, providing water for irrigation, human and animal consumption, and processing fruits and vegetables should be high on the list of priorities. Many farmers now are drilling bore holes (fresh water wells). This is a start but the water supply usually is minimal and the result may be that the water table is lowered in the future. A better solution than bore holes is necessary. Dams may be the answer.

To better understand the ways in which agribusinesses operate in production, processing and marketing, multidiscipline studies should be used to identify the needs of business that can be

provided through the research effort. In some way, personnel of the public sector must be educated and guided in their efforts to assist private business. Public sector people need to know more about the operation of private sector businesses in order to help them. Seminars, short courses and workshops attended by a mix of public and private sector people are recommended so problems and ideas for solutions can be exchanged freely. It is not adequate to assume that this exchange of problems and ideas will occur without a specific program to force the exchange. Mississippi State University has a good program of this type for working with agribusinesses. For information about that program, contact Dr. Ronald Brown, Associate Vice President and Director of International Programs, Mississippi State University.

Bibliography

Ross, Jack and Heron, Waldo. 1988. "Export Marketing and Postharvest Handling of Perishable Commodities in Thailand." Postharvest Institute for Perishables, University of Idaho and USAID.

Ross, Jack and Owusu-Sekyere, Kwabena. 1992. "Agribusiness and Public Sector Collaboration in Agricultural Technology Development and Use in Ghana: A Study of Postharvest Technology For Fruits and Vegetables." Abt Associates and USAID/AFR/ARTS/FARA.

Winrock International. 1992. "A Global Plan for an AID/R&D/AGR Postharvest Collaborative Agribusiness Support Program (CASP)." Winrock and Development Assistance Corp.

Hurelbrink, R., Marlowe, G., and Ross, J. 1993. "Role of Public and Private Sectors in Horticulture Development in UVA Province, Sri Lanka." Development Alternatives, USDA and USAID.

Ross, Jack and Hamilton, Joel. 1990. "Postharvest Needs Assessment For System B, Mahaweli Irrigation Project in Sri lanka." Development Alternatives, Postharvest Institute for Perishables.

Murray, Clive. 1990. "Packaging, Transportation and Marketing of Fresh Horticultural Produce in Thailand." FAO, Bangkok.

FAO and AFMA. 1986. "Improvement of Postharvest Fresh Fruits and Vegetbles Handling—A Manual." FAO and Association of Food Marketing Agencies in Asia and the Pacific (AFMA)."

McGregor, Brian. "Tropical Products Transport Handbook," USDA Agriculture Handbook, No. 668.

Asian Development Bank. 1987. "Agricultural Marketing Study—Malaysia."

Department of Agricultural Extension, Bangkhen, Bangkok, Thailand. 1088. "Fruits In Thailand."

Hoyt, Kenneth. "Solar Dryer Construction for Food Preservation." Postharvest Institute for Perishables and USAID.

Thompson, A. K. 1981. "A Report on a Consultancy to the Federal Agricultural Marketing Authority In Malaysia—Postharvest Handlng." Tropical Products Institute.

Morton, Julia. 1987. "Fruits of Warm Climates." Published by Julia Morgan, Library of Congress Catalogue Card Number 86–090575.

Wright, Geoff. 1982. "Corrugated Fibreboard Boxes—Their Design, Use, Quality Control, and Testing." Australian Paper Manufacturers, Ltd.

"Fibre Box Handbook," 1990. Fibre Box Assoc., Chicago.

Ryall, Lloyd, Lipton, Werner, and Pentzer, W. 1974. "Handling, Transportation, and Storage of Fruits and Vegetables." AVI Publishing Co.

Hall, Carl; Davis, Denny. 1979. "Processing Equipment for Agricultural Products." AVI Publishing Co.

Stewart, George and Maynard, Amerine. 1973. "Introduction to Food Science and Technology." Academic Press.

Livestock position paper

by

Martin Meltzer, Ph.D.

Executive Summary

Background. A decline in the per capita number of cattle and small ruminants has caused a marked reduction in the per capita consumption of beef, goat and sheep meat, and cows milk. The only sustained, albeit relatively small, increase in per capita consumption has been in poultry meat and hen eggs.

Multiple roles of livestock. In many African countries, the primary role of cattle is to provide draught power, milk and manure. Small ruminants also have multiple roles. Goats supply meat and milk for household consumption. Low offtake rates are a reflection of the complexity of livestock as productive assets. Other aspect of livestock's multiple roles is the indirect income and employment generated by livestock production.

Draught power, an important use of cattle, is usually associated with an increase in area cultivated. Some studies have shown a definite linkage between the use of draught power and increased yields. However, for many reasons, adoption rates for draught power are low. Other important crop-livestock interactions include the consumption of crop residues and the production of manure. Small ruminants (goats and sheep) are an important compliment to cattle and utilize natural resources that cattle often leave almost untouched. Chickens offer the chance of improving household nutritional levels without the investment and animal husbandry skills that cattle require. Another aspect of small ruminants and chickens is the gender related issue of ownership.

Constraints: Physical. Lack of pasture and browse, and poor quality of what is available, is probably the most important physical constraint facing livestock producers in Africa. The net impact is reduced productivity. The obvious "weak spot" in the genetic potential of Africa's indigenous cattle, goat and sheep breeds is low potential milk yields.

The economic impact of most diseases is not fully calculated. The epidemiology of some of these diseases (e.g., rinderpest) suggests that control should be considered at a whole herd level (i.e., country, regional), while the responsibility for other disease (e.g., tick-borne) may be devolved to farmer owned herds.

Constraints: Institutional. Livestock in Africa are woefully under researched. Cattle appear to receive the largest amount of resources for what little research activity exists. Adoption of new livestock technologies may be affected by population growth, access to markets and agroclimatic conditions.

Africa has a colonial and post colonial history of active government intervention in agricultural markets. These distortions have protected beef producers over a number of years. Milk producers, however, faced an implicit taxation.

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Suggestions for the future

Strategic issue: continue liberalizing markets. High priority should be given to the continued support of the liberalization of markets in Africa.

Strategic issue: veterinary services. Veterinary services in Africa have been characterized as one input that can be privatized. However, there must be a balance between the public and private sectors.

Strategic issue: funding and research institutions. Livestock research can be enhanced by assembling small, multi disciplinary teams. The role of governments, donors and scientists is to commit resources to those teams. The appropriate length of commitment is ten years or more.

Strategic issue: collaboration. Donors and governments should focus on encouraging true regional collaboration.

Research: general issues. Research on livestock should focus on systems.

Research: breeding. Priorities include; (1) cattle—increased milk production and more efficient (e.g., rapid) rate of gain; (2) small ruminants—increased rates of twining and milk production, and the cross breeding for dual purpose animals; and, (3) poultry—improving the feed efficiency of local breeds, and use of cross breeds to increase egg production.

Research: draught power. The adoption of animal traction very much depends upon local conditions. It is therefore not recommended that draught power be made the sole or central emphasis of livestock related projects and policies. But, it should not be forgotten.

Research: feed supply and stocking rates. In the near future, supplementary feeding of livestock may only be economically justified in specialized circumstances. One solution is the formation of bottom up, community controlled grazing schemes. The role of governments and donors is to provide technical advice, impartial mediation, and providing funding for infrastructure (e.g., fences, watering points).

Research: animal health. Governments and donors must continue and increase funding for research on new disease control and prevention technologies.

Research: funding for microenterprises. The possibility of financing micro enterprises need to be carefully researched, focusing on different production systems in different regions.

Research: value added. To compliment any growth in micro enterprises, the feasibility of adding value to livestock products should be researched.

Research: marketing information. Governments and donors should actively support the dissemination of market information (a public good).

Introduction

The human population in Africa has, over the past 30 years, grown much faster than the number of cattle and small ruminants. Only the chicken population has grown faster than the human population (Figure 1.A). The decline in the per capita number of cattle and small ruminants has caused a marked reduction in the per capita consumption of beef, goat and sheep meat, and cows milk (Figure 1.B). The average amount of per capita milk consumed for 1990-92 was approximately equal to the 1979-81 average, but still less than that consumed twenty or thirty years ago. The only sustained, albeit relatively small, increase in per capita consumption has been in poultry meat and hen eggs (Figure 1.B).

This drop in per capita consumption of animal protein has not adversely affected the per capita daily intake of calories, which has remained almost level for 30 years (Figure 1.C). Similarly, animal protein intake is reported as having been stable for the past 30 years (Figure 1.C). Despite this stability, there is a marked difference in regional food supplies. People living in developed countries in the northern hemisphere consume approximately one-third more calories, and six times the amount of animal protein, than people living in Africa (Figure 1.C). Winrock International (1992) and Sarma and Yeung (1985) provide a more detailed analysis of the past trends in the consumption of livestock products, and make predictions for the future.

When considering the needs of an ever increasing human population in Africa, three questions arise:

(1) Can livestock be used to improve the nutritional status of the growing human population (c.f., Figure 1.C)?
(2) Can production of livestock contribute to economic growth (i.e., can it generate employment opportunities)?
(3) Can livestock production systems be developed that will be sustainable?

This paper will focus on the roles of livestock and consider how livestock can contribute to improving human welfare in general, including the improvement of human nutrition. Small increases in, say, the amount of milk made available to pregnant mothers and young children will reduce the incidence of syndromes caused by nutrient deficiencies (e.g., protein-energy malnutrition, rickets due to lack of calcium) (World Bank, 1993). Such nutrition-based improvements in health are often long-term and sustained. Given the rapid growth of the human population, it is essential that such increase be sustainable.

The role of livestock in Africa

An examination of single year cross-sectional data from 39 sub-Saharan countries found that there was no direct link between the formation of per capita gross national product (GNP) and

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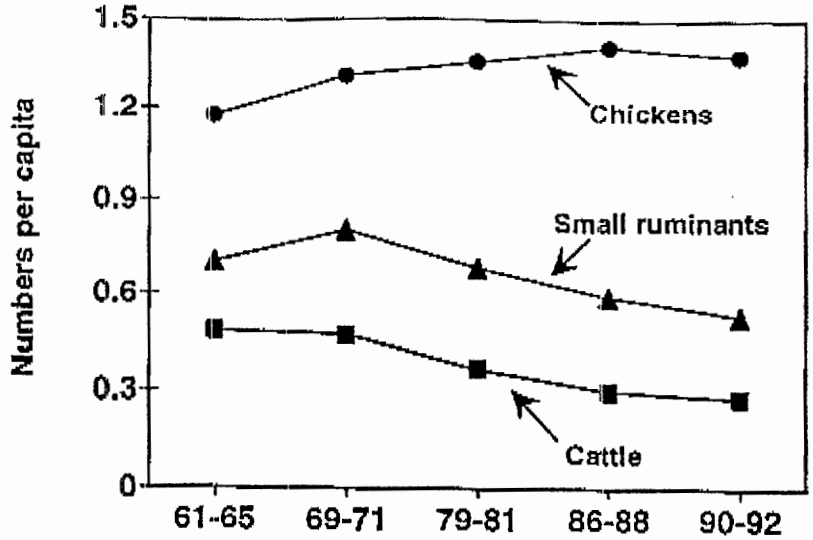
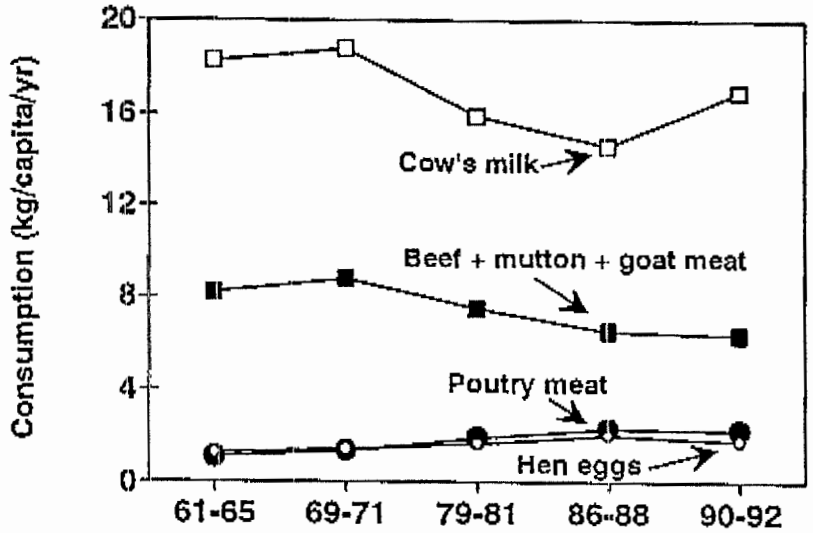
Figure 1: Trends in African livestock production and consumption

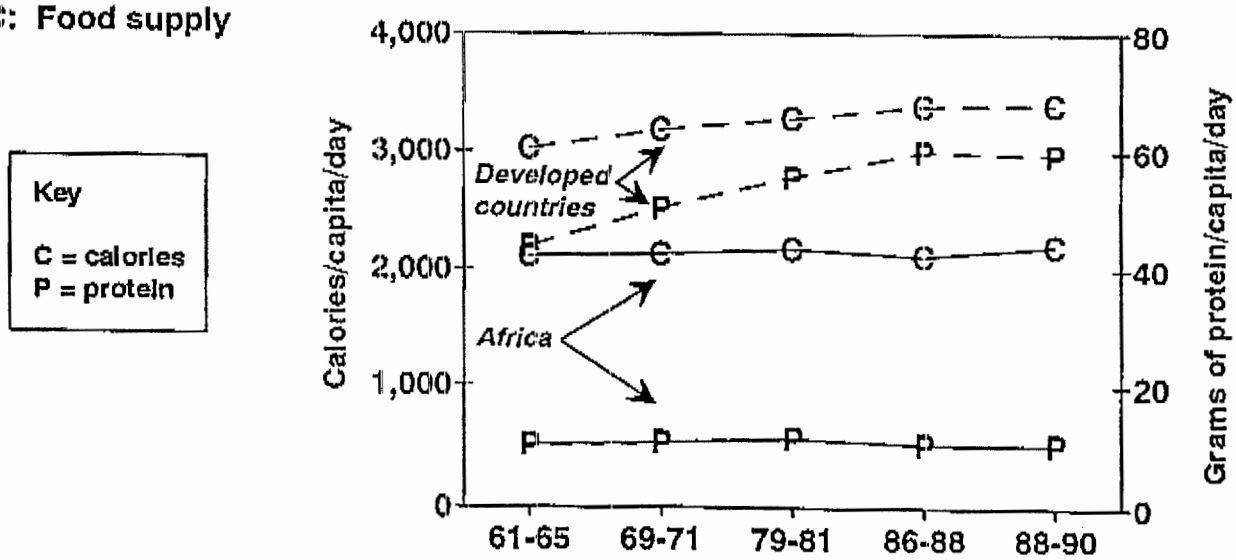
A: Numbers



B: Consumption



C: Food supply



Note: Estimates for protein consumption for 86-88 are from 87-89.
Sources: FAO Production Yearbook, various volumes, 1973-1993.

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the number of cattle per capita (Figure 2). That is, the number of cattle cannot be used to predict GNP (or vice versa). Similar results were obtained when examining the linkage between small ruminants and GNP. Further, in any given year, per capita GNP does not predict the value of livestock products (meat, milk, eggs, wool, hides and skins) (Figure 3).

This does not mean to say that livestock do not contribute to the economies of Africa. By some estimates, livestock products contribute 8 percent of total gross domestic product, and 25 percent of agricultural domestic product (Winrock International, 1992). Some studies have shown that farmers can earn up to 50 percent of their cash income from the sale of livestock products (Winrock International, 1992). Yet, Lele and Stone (1989) show that sales of livestock products contributed only 8 percent of the total income among farming households in Malawi. Communal land farmers in Zimbabwe have been found to obtain between 2 percent and 16 percent of their cash income from livestock products (GFA, 1987).

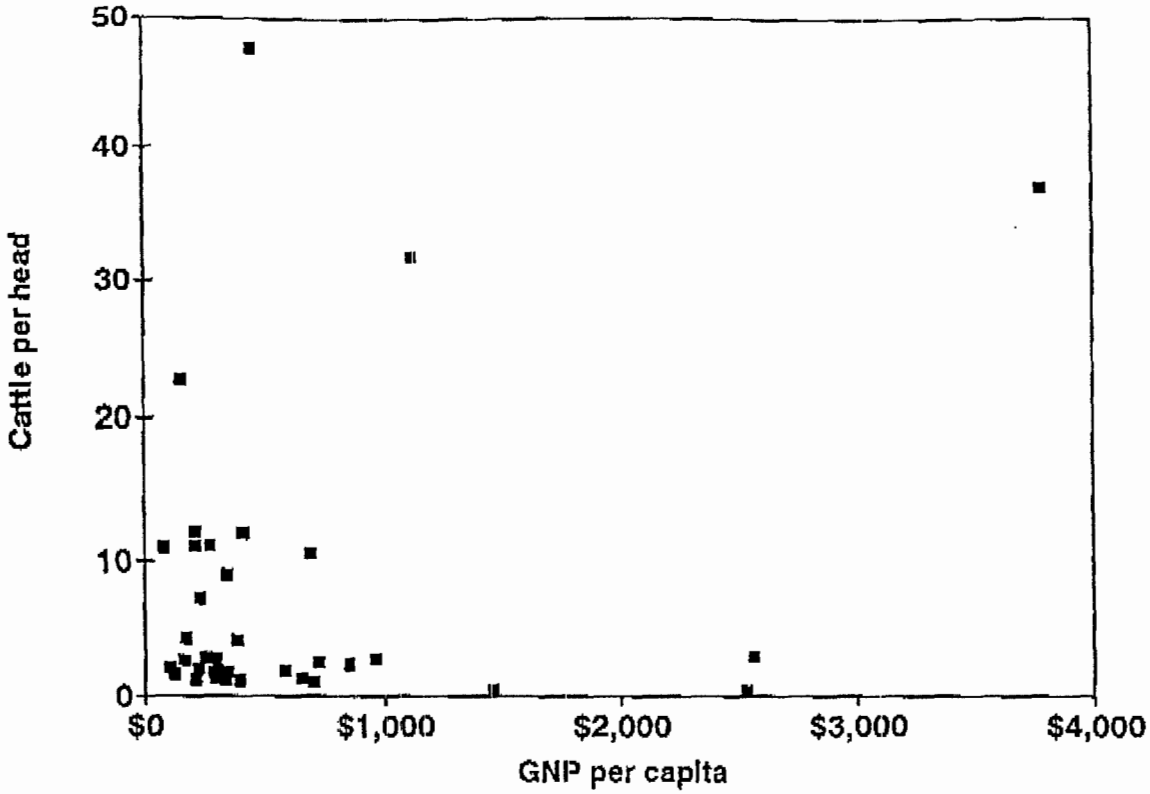
Using long term data, it is possible to calculate relatively large and statistically significant correlations between growth of GNP and growth in the value of livestock products (H. Blackburn, personnel communication). However, correlation does not define cause and effect. The long term data used to calculate such correlations does highlight the point that livestock is a slow maturing investment.

Offtake rates and livestock production. Low offtake rates is one of the main reasons why cattle and other livestock do not appear to make a rapid and direct contribution to GNP and cash incomes. In Africa, the average number of cattle slaughtered as a percentage of the total herd for the years 1979–81 and 1987–89 was 10.9 percent and 11.3 percent, respectively (FAO, production yearbook, 1990). In developing countries, the average percentage of slaughterings for the same time periods was 34.0 percent and 36.5 percent (FAO, production yearbook, 1990). Matthewman and Perry (1985) provide a specific example of low offtake rates, showing that offtake among herds owned by Zambian small-scale farmers is equal to 9.7 percent. This low offtake rate means that cattle are kept for an average of 8 to 10 years before slaughter. Hence the need to consider cattle and other livestock as long term investments.

Imports and exports of fresh or chilled beef and other meats are, on average, too small to noticeably affect GNP figures or offtake rates. The average import of beef in 1978–80 was 0.24 kg/capita/yr and for 1988–90 the average was 0.21 kg/capita/yr. The average export in 1978–80 was 0.19 kg/capita/yr, and in 1988–90 was 0.11 kg/capita/yr (FAO, trade yearbook, 1991, 1981). Compared to total consumption of beef, mutton and goat meat (Figure 1.B), beef imports amount to 3 percent of consumption.

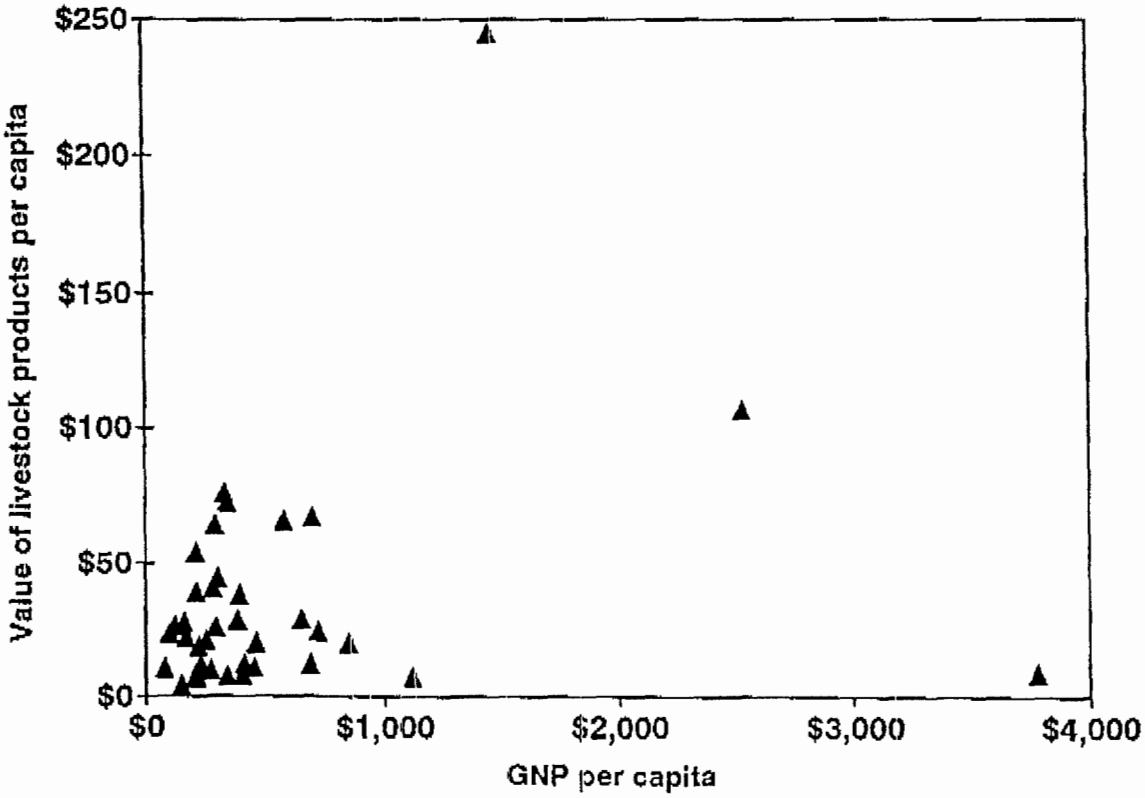
Goats and sheep also have relatively low offtake rates, averaging between 30 percent (1979–80) and 32 percent (1987–89). This is noticeably lower than the 44 percent experienced in the developed countries (FAO, production yearbook, 1990). The low offtake rate means that goats and sheep are kept for an average of over 3 years.

Figure 2: Relationship between GNP and cattle numbers



Sources: World Bank, 1989, 1993; FAO, animal health yearbook, 1991.

Figure 3: Relationship between GNP and value of livestock products



Sources: World Bank, 1989; Winrock International, 1992.

Multiple roles. To worry about low offtake rates and cash values is to miss the central issue: Why are cattle and other livestock kept? In Zimbabwe, the primary role of cattle is to provide draught power, milk and manure (Table 1: see also Scoones, 1992). Multiple roles for cattle are not unique to Zimbabwe. Bailey (1982) made the same observation in Botswana, whilst Wilson (1986) details how agricultural production systems and the roles played by livestock species change in response to differing agroclimatic conditions in West Africa. In multi-role systems, the sale of cattle for meat is a residual event, occurring only when the animal in question is past its productive life, or the owner has an unplanned monetary need, or a disaster (e.g., drought) occurs. Small ruminants also have multiple roles.

In Zimbabwe, goats supply meat and milk for household consumption. Occasionally, they are sold to provide cash for education, arrange marriages, provide gifts, and supply family and spiritual functions. Goats are so important to the household that it was found in Zimbabwe that the cattle to goat ratio was fairly stable (1:1), and that this ratio quickly re-established itself after each disposal of goats (Gesellschaft fur Agrarprojekte in Ubersee, GFA, 1987). In summary, low offtake rates and cash income are not an indication of inefficiency, but a reflection of the complexity of livestock as productive assets.

Arguments stressing the multiple roles of livestock need to be made, because researchers and government officials have often indicated that the low offtake rate of livestock is due to the social functions of livestock (Table 1). However, Mtetwa (1978) and Steele (1981) argue that the "cattle complex" is a myth, and even seemingly social functions such as bride price are in fact direct economic functions.

Pastoralist herds and multiple roles. Livestock owned by pastoralist also have multiple roles (Konczacki, 1978; Dahl and Hjort, 1976). These multiple roles also mean that pastoralist might not increase sales of beef when producer prices increase. This was the case when Maasai pastoralists were settled on ranches in Kenya, which resulted in a minimal movement toward commercial beef production (King et al., 1984). Cossins and Upton (1987) report that the Borana in Ethiopia keep herds primarily for milk production, although 30 percent of their energy intake comes from purchased grain.

Overall, Cossins and Martin found the system used by the Borana to be very efficient, with little scope for improvement. Coughenour *et al.* (1985) support that conclusion by stating that the energy utilization of the Ngisonyoka Turkana (Kenya) system of livestock production is "consistent with ecological patterns that promote rather than diminish ecological stability under stress." Although the pastoralist multiple role systems of raising livestock may be ecologically sound, the key for sustaining such systems is undoubtedly low population densities (human and livestock). With Africa's growing human population, pastoralist systems must and are changing (Shanmugaratnam et al., 1992). As the experience in Kenya has shown (King et al., 1984), adaptations are unlikely to result in the development of single product enterprises (e.g., beef production).

Table 1: The role of cattle: rankings from two surveys conducted in Masvingo province, Zimbabwe.

Danckwerts, 1974		Gambiza et al., 1987	
Use	Rank[a]	Use	Score[a]
Ploughing	233	Draught power	2,016
Bank	123	Milk	1,186
Milk	8	Manure	1,071
Selling	5	Sale	951
Manure	4	Meat	648
Bride wealth	3	Lobola[b]	439
Meat	1	Carting	314
Don't know	123	Hides	129
Too old to comment	69	Spiritual ceremonies	128
Absent	418		
Total replies	987		

Notes: (a) The methods of ranking and scoring used in the two surveys are not directly comparable.
(b) Lobola is bride price.
SOURCES: Meltzer, 1990; Gambiza et al., 1987; Danckwerts, 1974.

Impact of multiple roles. The most important effect of the multiple roles of cattle and other livestock is that herds are not primarily meat producing herds (Due and Magayane, 1990; Le Roux et al., 1978). This means that offtake will not automatically rise with increases in producer prices (Simpson and Sullivan, 1984; Sanford, 1982). It is, therefore, a mistake for governments, donors and analysts to evaluate policies and projects designed to increase livestock productivity principally in terms of potential amounts of extra meat and milk produced. Since approximately 75 percent of the cattle in Africa are associated with small-scale farms (Brumby and Trail, 1986) multiple roles are the norm for livestock. Multiple roles are not a new phenomena. Out of 27 precolonial tribes studied in semiarid east Africa, 21 combine farming with cattle ownership (Pinagli et al., 1987, Table 6-3).

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Valuing the multiple roles. The fact that many livestock products, such as draught power, are used as inputs in crop production schemes makes the valuation of livestock and their contribution to development in Africa difficult to measure in the short term (c.f., Figure 3). However, GFA (1987) used data from Zimbabwe to attempt an internal valuation (i.e., shadow prices) of draught, manure, milk, meat and natural herd growth. It was found that the value of draught and manure was approximately equal to that of meat and milk. In the less arid regions, the multiple roles of cattle were as valuable as crops. In the drier regions the value of livestock was noticeable larger than that of crops. Scoones (1992) also conducted a similar exercise for oxen, cows and goats and found that, except for goat production on sandy soil savanna areas, livestock's multiple roles provide a high rate of return.

Other aspect of livestock's multiple roles is the indirect income and employment generated by livestock production. Haggblade and Hazell (1989) found that, in Africa, agricultures value-added multiplier increased from 1.28 for hoe cultivated crops to 1.47 for ox cultivated crops. That is, the use of draught power increases non farm income through the creation of jobs such as blacksmiths and machine repairers. Approximately 90 percent of these multipliers were due to consumption effect. Farmers using draught power bought more goods and services than hoe cultivators.

Thus, a systems approach must be taken to evaluate the total contribution of livestock to crop production and human welfare. Sanford (1987?) list five pathways in which livestock become part of a system of producing crops. These are (1) animal traction and transport; (2) manure; (3) livestock's feeding practices on natural and cultivated vegetation; (4) impact of livestock hooves on soils and vegetation; and, (5) impact of forage legumes on yields of subsequent crops. The last pathway is still a rather rare occurrence in Africa, and since more is known about the first three pathways, this paper will now focus briefly on those pathways.

Draught power. Draught is often one of the most important reasons cited for owning cattle in Africa (Table 1). Examining the value of traction power provides opportunities to explore options for improving productivity. Does it increase yields and productivity? Is it profitable for farmers to adopt?

The answer to these two questions is not absolutely clear. Pingali et al. (1987, Table 7-6) examined 22 farm-level surveys, covering 10 countries[11], which measured the impact of draught power on crop output. They found that the use of draught power is usually associated with an increase in area cultivated, but not necessarily with an increase in yield. Francis (1988) also found that early adopters of ox draught power in northern Zambia increase area cultivated. However, there are other studies which show a definite linkage between the use of draught power and increased yields. For example, Theisen and Marsha (1974) showed that cattle ownership was closely linked to crop yields in Zimbabwe, as did Shumba (1985), and

[11]These countries are: Mali, Senegal, Chad, Cameroon, Burkina Faso, The Gambia, Cote d'Ivoire, Kenya and Sierra Leone.

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GFA (1987). Barrett (1989) reviews other studies showing similar responses in yields to the use of tillage. In more general terms, Savadago et al. (1994) found in Burkina Faso that, when compared to farmers using hand hoes, farmers using draught power had higher coefficients of average productivity (AP) and marginal productivity (MP). Jaeger and Matlon in Burkina Faso (1990), and Adesina in Mali (1992), both found draught power to be profitable, with the later showing draught power gave an internal rate of return of 35-45 percent. Haggblade and Hazell (1989) found that the use of traction power in Africa increases the linkages to nonfarm income (i.e., diversification). Despite these benefits, Delgado and McIntire (1982) found from studying 125 animal traction projects in Francophone west Africa that rates of adoption are low. For example, in Mali the peak adoption rate in the mid-1970's was 2 percent per year.

Constraints to adopting draught power. There are many problems associated with adopting draught power. First, in many African soils, ploughing is almost impossible until the first major rains have softened the earth. Second, many farmers do not own sufficient numbers of cattle or other draught animals to compose an adequate team. A farmer must own a total of 8-10 head in order to assemble a 2-4 head ploughing team (Bratton, 1984). Le Roux et al. (1978), Bratton (1984), and the GFA study (1987) all found that approximately 60 percent of Zimbabwean farmers did not have sufficient draught power.[12] The shortage of cattle per farmer, and therefore draught power, continues to worsen (Figure 1.A). Third, training a draught team and the novice farmer takes a great deal of time. Jaeger and Matlon (1990) found that, in Burkina Faso, farmers maximized area cultivated by draught power only after 7-9 years of use. Fourth, draught power may not, by itself, be sufficiently profitable to warrant the considerable investment in capital and labor costs (Delgado and McIntire, 1982). Adesina (1992) found that the highest returns to ox cultivation in Mali occurred when oxen-plough-weeder technology is used. Thus, in order to maximize returns, farmers need to purchase more equipment. Fifth, there is often a problem with feeding the draught animals during the dry season. The problem of stocking rates and feeding livestock in general will be discussed later (under physical constraints to increasing productivity).

Crop residues and manure. Another part of the livestock-crop interaction and livestock system is the production of manure, often accomplished through the consumption of crop residues. McIntire et al. (1992) review the benefits of manure on crop yields and found, on average, only a weak positive effect of manure and mulch on crop yields. Thus, manure should only be recommended over chemical fertilizers when it is cheaper to produce, distribute, and apply. The authors also found that many experimental results that are used to demonstrate the benefits of manure often treat manure as a free good, and that experimental application rates are often much higher than those found on farms. Nonetheless, farmers still attach some value to the manure produced by their livestock (Table 1).

[12]In relation to size of herd, sufficiency of draught power depends upon the composition of the herds. Herd composition deserves a separate study, but it is worth noting its role in determining availability of draught power.

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Livestock consumption of residues can be an important part of total feed intake. Sanford's (1987?) review of the available literature found that up to 40 percent of the total feed intake of cattle can consist of residues. For goats and sheep this figure was only 5-12 percent. The consumption of crop residues by livestock can be considered a means of utilizing a resource. Sanford (1987?) cites a study from Niger which suggested that the gross value of output per hectare of cereals increased by 17-35 percent when livestock consumed the crop residues. However, there may be some negative effects associated with the use of crop residues to feed livestock and thus produce milk, liveweight gain, and manure. Crop residues left on the fields can reduce wind and water erosion, add nutrients and improve soil composition. I am unaware of any study that compares these factors with and without feeding the residues to livestock.

Goats and sheep. Small ruminants (goats and sheep) are an important compliment to cattle and are part of the total system (GFA, 1987). King et al. (1984) found that small ruminants helped the Maasi survive the effects of drought. They also found that, due to the propensity for goats to browse more than graze, goats were better able to cope with the effects of degradation caused by intensive grazing pressure. Cossins and Upton (1987) found that the Borana relied upon their small ruminants to provide milk.

Holdings of small ruminants compliment cattle herds. By browsing more than grazing, they utilize natural resources that cattle often leave almost untouched. Further, the investment of several goats against one cattle gives the owner greater flexibility of disposal (Scoones, 1992). If a farmer needs money (school fees, inputs, etc.), selling one cow represents the liquidation of a large asset, and may realize more money than is actually needed. The farmer then has to find a means of reinvesting the unused sum. Thus, owning cattle and small ruminants represents a means of reducing risk and providing greater flexibility in liquidating assets.

Gender aspect. Another aspect of small ruminants in Africa is the gender related issue of ownership. In many African societies, small ruminants are considered more of a women's responsibility or asset. For example, among the Hausa in south Niger, women own 80 percent of the total small livestock (Shanmugaratnam et al., 1992). However, distribution of livestock assets are generally not gender neutral. Due and Magayane (1990) found that, in Zambia and Tanzania, female headed households, face shortages of labor and credit, and generally have less assets than male headed households. GFA (1987) found that female headed households in Zimbabwe have fewer cattle and goats than male headed households. Since goats and sheep represent smaller initial investments, both studies contained recommendations that female headed households be encouraged and assisted to expand their holdings of small ruminants.

Shanmugaratnam et al. (1992) also found that many women in pastoralist tribes own few or no livestock. It such situations they may have exclusive milking rights, giving them the opportunity to earn their own income. However, the authors point out that many projects focusing on livestock bypass or ignore the gender issue. For example, women rarely have access to credit to purchase the nucleus of their own flocks or herds. Shanmugaratnam et al. (1992) voice concern that starting formal milking cooperatives may remove women's access to the milk. To date, there are no data to study the issue.

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Chickens and other livestock. Although chickens obviously constitute an important part of livestock holdings (Figure 1.A), their roles and economic importance is almost completely ignored by analysts, policy makers and planners. There has been, of course, some research conducted on the husbandry and nutritional aspects of raising poultry in the tropics (see Webster and Wilson, 1980). Most rural household own some poultry. In Zimbabwe, over 95 percent of surveyed households owned 15–20 hens (GFA, 1987). Other livestock, such a pigs and rabbits are rather uncommon in some areas and regions.

It is a pity that such species have not been given more attention. Chickens and rabbits offer the chance of improving household nutritional levels without the investment and animal husbandry skills that cattle require. Also, the lower investment requirements provides opportunities for women with few resources to earn income selling meat and eggs.

Physical constraints to increasing productivity

Feed/grazing/stocking rate. Lack of pasture and browse, and poor quality of what is available, is probably the most important physical constraint facing livestock producers in Africa (e.g, Winrock International, 1992; McIntire et al., 1992). Most of the livestock in Africa are grazed or browsed on communal pastures, which are often characterized as being overstocked and therefore overgrazed (e.g., Fowler, 1981). The net impact of this apparent overstocking is reduced productivity, evidenced by slow weight gains, and a seasonal pattern of weight gains and losses. This reduces conception and calving or kidding rates.

This has led some to consider the case for optimal stocking rates, and to model such rates (e.g., Koen, 1987; Hart, 1972). Some models even consider the fact that multiple roles mean different optimal stocking rates. For example, commercial beef ranchers will want to maximize return per hectare, while small-scale farmers will probably opt for maximizing number of head (Gammon, 1983). The difference between the two objectives has much to do with land tenure. The large-scale commercial farmer owns and controls access to his/her land, while the individual communal farmer has no control over access and competes with all other farmers in the area for grazing. In the latter case, since the individual farmer cannot be guaranteed of the resources to maximize weight gain per head, the most risk averse strategy is to own as many animals as possible. This has may lead some to call for land tenure reform as the only real and lasting solution to overstocking. Another common call is for destocking campaigns, often government controlled (e.g., Fowler, 1981).

Detailed discussions of land tenure reform, optimal stocking rates and destocking is beyond the scope of this paper. For the purposes of this paper, it is sufficient to point out that: (1) techniques for measuring stocking rates have yet to be fully refined; and (2) government run destocking campaigns in Africa have historically been very unpopular, sometimes leading to political and civil unrest (see Behnke and Scoones, 1992; Meltzer, 1990). Behnke and Scoones (1992) and Scoones (1987) have pointed out that it may be impossible to guess or estimate *sustainable*, optimal stocking rates. It has been argued that there is a lack of

methodologies and techniques suitable to rapidly measure and index the ecological impact of animal and human populations (Meltzer and Hastings, 1992; Meltzer, 1990).

Genetic potential. Africa's indigenous sanga breeds are well adapted to the hot climate, and can often gain weight faster than exotic *Bos taurus* breeds (e.g., Tawonezvi, 1989; Brumby and Trail, 1986). Much of the supposed low performance of the indigenous breeds can be traced to environmental conditions, such as poor pasture (see above), than to genetic potential (Table 2). The obvious "weak spot" in the genetic potential of Africa's indigenous breeds is milk potential. Indigenous breeds have low milk yield, and when milk is consumed by humans, the weaning weights of calves can suffer (Table 2). An example of the low milk yields is the average of 470 kg/yr obtained from the Fulani transhumant herds, of which 170 kg/yr is consumed by humans (Nuru and Buvanendran, 1985). Konandreas et al. (1983) found that a mixed beef-dairy strategy using cross breed was an optimal strategy in Botswana. Under the conditions examined, cross bred cattle (Simmental x Tswana) had a maximum yield potential of 3,500 kg milk per lactation versus only 1,900 kg from Tswana.

Table 2: Production system, weight gain, and calving percentages

		Weight (kg)				Calving rate (%)
Country	Breed/system	Birth	Wean	2 yrs	4 yrs	
Mali	Sudan Fulani/					
	traditional	17	55	125	200	54
	ranch	21	79	220	280	77
Nigeria	White Fulani/					
	traditional	20	55	140	240	46
	ranch	24	96	245	350	89
Ethiopia	Boran/					
	traditional	20	55	150	260	55
	ranch	25	180	265	420	78
Botswana	Tswana/					
	traditional	26	120	260	300	46
	ranch	31	180	360	400	74

SOURCE: Adapted from Brumby and Trail, 1986.

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Indigenous African sheep and goats also have much lower milk yields than cross breeds or European exotics. For example, Wilson (1986) records a lactation yield of 50 kgs from Macina sheep in Mali. Webster and Wilson (1980) found that cross breed goats have the potential to produce double the milk of indigenous breeds (400 kg/yr vs. 200 kg/yr).

Health. The major diseases afflicting cattle, small ruminants and poultry in Africa are presented in Table 3. The groupings reflect both the assumed economic impact and how the disease are spread. The latter has important consequences on control and prevention efforts. It is important to emphasize that the economic impact of these diseases is not fully calculated. Justification for control often centers on a few oft-repeated maximum mortality rates, such as 90 percent for rinderpest (Yilma, 1989; Walsh, 1986) and up to 40 percent for heartwater (Lawrence et al., 1980). De Haan and Bekure (1991) estimate that losses due to disease related mortality among African livestock are equal to US$2 billion per year, with another US$2 billion due to non lethal losses (e.g., lower conception rates, increased abortions, reduced weight gain, lower milk yields). Mukhebi et al. (1992) estimated that, among 11 countries, the tick-borne disease theileriosis causes losses worth US$168 million per annum. This estimate included the value of an estimated theileria related mortality of 1.1 million cattle, as well as the cost of applying pesticides to control the tick vectors.

The epidemiology of some of these diseases suggests that the control of the Group I diseases should be considered at a whole herd level (i.e., country, regional), while the responsibility for controlling Groups II and III may be devolved to individual, farmer owned herds. This is because the viral, epidemic diseases (Group I diseases) can be indiscriminately spread. For example, CCPP can be rapidly spread among previously unexposed and unvaccinated goat flocks by coughing, resulting in mortality rates of up to 100 percent (Lipner and Brown, 1994).

Technically effective vaccines exist for the diseases in Group I. For example, the Plowright tissue cultured vaccine for rinderpest will protect almost 100 percent of the cattle vaccinated. Unfortunately, the vaccine must be kept in a cold chain, at 4°C, up to the point of administration. This creates a severe logistical problem when trying to vaccinate herds in remote parts of Africa (Walsh, 1987). A new recombinant live virus vaccine has been developed for rinderpest (Yilma, 1989). This vaccine is freeze dried, allowing storage and transportation without cooling, and it is potentially cheap to produce. A freeze dried vaccine for CCPP has also been developed (Lipner and Brown, 1994).

Very few *effective* vaccines exist for group II parasitic diseases. "Vaccines" are marketed for the tick-borne diseases anaplasmosis, babesiosis, and heartwater. However, these vaccines consist of live or killed whole organisms. The live vaccines essentially confer immunity by infecting the vaccinated animals. An infection-and-treatment system has been developed for theileriosis. No vaccine exists for trypanosomiasis. Vaccines exist for the vector-borne viral diseases, Nairobi sheep fever and Rift valley fever.

Table 3: Major livestock diseases in Africa

Group	Cattle	Small ruminants	Poultry
Group I: Highly contagious	Rinderpest Contagious bovine pleuropneumonia Foot and mouth disease	Peste de petits ruminants (PPR) Contagious caprine pleuropneumonia (CCPP)	Newcastles disease
Group II: Vector-borne parasitic	Trypanosomiasis Tick borne Theileriosis (East Coast Fever) Cowdriosis (Heartwater) Anaplasmosis Babesiosis	Trypanosomiasis Tick borne Theileriosis (East Coast Fever) Cowdriosis (Heartwater) Anaplasmosis Babesiosis	
Fungal	Dermatophilosis	Internal parasites	
Vector-borne viral	Rift valley fever	Nairobi sheep fever Rift Valley fever	
Group III: Diseases of intensification	Mastitis Nutrient deficiencies Anthrax	Anthrax Nutrient deficiencies	Newcastles disease Nutrient deficiencies

SOURCE: Adapted from Winrock International (1992). Eicher and Baker, 1982.

Outside of vaccines, chemotherapy can be used to control and treat animals infected with vector borne diseases. The common antibiotic, tetracycline, is effective against heartwater and theileriosis, while specific drugs have been developed against trypanosomiasis and babesiosis. However, drugs are usually too expensive to use on a large scale. Thus, efforts to control vector borne disease have focused on vector control, usually by applying insecticides. This is costly and leaves the animal population vulnerable to epidemics should the system of delivering and applying pesticides breakdown (e.g., Lawrence et al., 1980).

Recent developments in vector control include the tsetse fly trap (e.g., Knols et al. 1993; Dransfield et al. 1991), the development of a tick decoy to control ticks that spread heartwater (Norval et al. 1994), and the concept of using economic damage thresholds to apply pesticides (Meltzer & Norval 1993). The later is similar to integrated pest management for crops.

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With the failure to develop vaccines, research has focused on resistance to parasitic diseases, especially resistance against trypanosomiasis. Certain breeds, such as the N'Dama and the West African Shorthorn, have proven to be less susceptible to trypanosomiasis than other breeds (Murray et al., 1982). It must be noted, however, that such resistance is not absolute, and even N'Dama cattle can succumb to severe challenges. Further, it should be asked why, after several thousand years, trypanotolerent cattle make up less than 5 percent of the estimated 147 million cattle raised in areas where trypanosomiasis is endemic (Williams et al., 1993)? One of the reasons is that the trypanotolerent breeds, when removed from tsetse fly areas, are notably smaller and less productive than other zebu breeds such as the Boran (Murray et al., 1982).

Institutional constraints to increasing productivity

Lack of research—Using publications as an indicator of research activity, it was found that an avearge of just 26 articles on livestock per year are produced (c.f., Box 1). Considering the importance of livestock (Figure 1), this would seem to indicate that livestock in Africa are woefully under researched. If the number of publications is used as a guide to resource distribution, then cattle receive over 40 percent of resources devoted to research.

An experiment: Measuring the amount of research on livestock

A simple experiment was conducted to gauge the amount of total research conducted on livestock in Africa, and the proportions of the total directed at cattle, sheep, goats and chickens. The experiment was carried out by accessing a specific computerized database (Agricola, Silver Platter, Inc.) and programming for a list of all articles published between 1970 and June 1994 on predefined topics. The program had to select articles containing the following key words: (1) species (cattle, sheep, goats, chickens or hens); and (2) Africa or one of 12 preselected African countries (Botswana, Cameroon, Chad, Ethiopia, Kenya, Mali, Niger, Nigeria, South Africa, Senegal, Tanzania, and Zimbabwe). The results are presented in the table below. On average, only 26 articles per year per country are produced.

Table: Results of searches for literature on livestock research

Species	Number of articles		
	Africa	Country specific[a]	Totals
Cattle	906	2,190	3,096
Goats	413	719	1,032
Sheep	825	1,300	2,125
Chickens	409	867	1,276
Total			7,529

Note: (a) Country specific refers to one of 12 countries. See text.

There are many problems with the methodology used. The database was not necessarily comprehensive, and many articles published in reports and journals are probably not indexed. Finally, search terms are not precise. For example, the use of the term "hen," caused many articles with the word "hence" to appear in the search.

Market distortions. Africa has a colonial and post colonial history of active government intervention in agricultural markets. Many governments set both producer and consumer prices for beef and other commodities. Williams (1993) studied the impact of these distortions in five countries (Ivory Coast, Mali, Nigeria, Sudan, and Zimbabwe), and found that these distortions protected beef producers over the period studied (1970–86). That is, internal, regulated beef prices were higher than equivalent border or trade prices. Mutton in Nigeria, Ivory Coast, and the Sudan also received higher than equivalent boarder prices. Milk producers, however, were paid less than equivalent border prices (i.e., milk was taxed). Wieblet (1992) found that the mixture of direct subsidies to Zimbabwean producers and indirect taxes from 1980-86 often resulted in producers being taxed. The one exception was

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beef producers, which consistently received subsidies which over-compensated for any effects of indirect taxation.

Such distortions in pricing create many negative impacts. First, the emphasis on beef exports and high prices may encourage a farmer to sell hard-to-replace cattle for some quick cash. A more sustainable approach might be to keep the cattle and use them as an inputs in crop production. Second, the emphasis on beef exports is reflected in the agendas of various research institutions. To meet overseas consumer demands, researchers and extension agents focus on exotic breeds, such as the Hereford, reducing the priority level of indigenous breeds. Third, because small ruminants and poultry are rarely part of government price controls, they are often ignored when setting government funded research agendas. Fourth, indirect taxation of milk may stunt the growth of an industry which provides a needed and renewable source of animal protein.

African governments are not the only culprits guilty of distorting markets for livestock. The European Union has impacted beef production in Africa in at least two notable ways. First, since the mid-1980's, the EU has dumped ever increasing amounts of cheap, low quality beef and chicken in west Africa. The amount dumped has leapt seven fold in seven years, and has depressed local market prices to the point where local producers cannot compete (The Economist, 1993). The second EU intervention is via set quotas for Africa beef imports into the EU under the Lome convention. Although these quotas are relatively small (Zimbabwe and Botswana have approximately 10,000 MT each), the per unit price is often higher than that received on the world market. However, these quotas have severe restrictions and conditionalities placed on them. Some of the most restrictive conditions involve the control of foot-and-mouth disease. Both Botswana and Zimbabwe have had to erect game control fences and Zimbabwe has designated catchment (foot-and-mouth free) and non catchment areas. There are regulations which limit the movement of cattle from non catchment areas, and farmers in non catchment areas face lower producer prices. Private abattoirs in the non catchment areas pay between 9–10 percent less than those in catchment areas, and the government parastatal pays between 1 and 7 percent less for non catchment area beef (super grade; The Farmer, 1993). I am unaware of any cost benefit analysis of these quotas which includes the ecological and environmental impact of the game fences.

Other considerations

Adoption of new technologies. Adoption of new livestock technologies by farmers in Africa is often low. Sullivan et al. (1978) studied the adoption rate of 22 different livestock management practices in Tanzania, and calculated adoption scores. There was a wide variability in adoption scores, which were not closely related to herd size, family size, or age of head of household. They found that the prime reason for adopting new management practices occurred when the economic and social benefits accrued within the existing multi role structure of herds.

In contrast, zero-grazing milk production techniques have become quite widely adopted in certain areas of Kenya. One of the motivating factors has been extra income from the sale of milk, principally to urban and peri-urban areas (McIntire et al., 1992; A. Mukhebi, personal communication). One cause of the different rates of adoption may be population densities, as proposed in the Boserup hypothesis (Boserup, 1965). However, increasing population density is an insufficient condition to promote adoption of new technologies. It may well be that rapid growth in human population prevents adoption of new technologies by eating away at capital savings and physical resources needed for investment in a new technology (Lele and Stone, 1989). Pingali et al. (1987) felt that both population growth and access to markets are the main determinants of agricultural intensification. McIntire et al., (1992) support this conclusion and add agroclimatic factors as a third component which determines the type of crop-livestock system adopted by farmers. However, I am unaware of any study which statistically analyzes the relationship between adoption of new livestock technologies, population densities, access to markets (e.g., kilometers of paved road per capita; number of market towns per population density), and agroclimatic factors.

Other government policies, beyond prices and taxation (see above), can also hinder the adoption of new technologies. For example, Turk (1994) and Lipner and Brown (1994) detail the problems of adopting a new vaccine against CCPP (Table 3) in Kenya. Part of the problem was that the Government of Kenya classified CCPP as an epidemic disease, and control is treated as a public good. Unfortunately, the Kenyan government has insufficient funds to purchase the vaccine and distribute free to farmers. Despite documented need and potential demand, the vaccine has yet to be commercialized.

Suggestions for the future

Winrock International (1992), McIntire et al. (1992) and Pingali et al. (1987) discuss research priorities and agendas, and means of extension, in greater depth than is possible in this brief paper. Readers are therefore urged to refer to these references. Drawing on the data concerning issues facing livestock and sustainability given above, some priorities and issues for research on livestock in Africa are presented below. Some strategic issues are presented first, followed by some specific research targets.

Strategic issue: continue liberalizing markets. Beyond generously supporting a few farmers producing export quality beef (e.g., Williams, 1993; Wieblet, 1992), government control of livestock marketing systems has generally failed to noticeably improve the welfare of livestock producers. Thus, a high priority should be given to the continued support of the liberalization of markets in Africa. Although economic reform programs in Africa are beginning to generate a "flicker of light," there is still a lot to be done (The Economist, 1994).

Re-evaluation of exchange rates is another example of macro economic and market liberalization policies that offer the chance of improving the conditions for Africa's livestock industry.

The devaluation of the CFA in early 1994 has reportedly revitalized the local livestock industry in west Africa which was previously being undercut by cheap meat imports from the EU (H. Blackburn, personal communication; *The Economist*, 1993).

It is also important to work on a re-evaluation of some donor policies toward African livestock markets. Both the practice of exporting cheap meat to Africa and agreements such as the Lome convention, with its beef import quota, should be re-evaluated. Re-evaluation should consist of a thorough cost benefit analysis which considers financial, economic and socio-economic impacts. Further, such an evaluation must consider the probability of sustainability, categorizing it as a cost or benefit.

Strategic issue: public goods. Even after a most comprehensive liberalization policy has been successfully implemented, there will remain some public goods associated with livestock production. For example, a government might allow private abattoirs to compete with an official meat marketing parastatal. The public interest might be served by expanding and reenforcing the food safety system (food inspectors, etc.). Other examples of public goods is the control and prevention of epidemic diseases (e.g., rinderpest), the provision of market information, and extension services. Perhaps the most important public good is infrastructure, such as paved roads between market centers.

The sustainability of a livestock project or sector may depend upon the sustainability and reliability of such public goods. Thus, any project which seeks to improve and promote animal production should include an evaluation of the ability of the government to continue to deliver, or improve its delivery of, such public goods.

Strategic issue: veterinary services. Veterinary services in Africa have been characterized as one input that can be privatized (e.g., Umali et al., 1992; de Haan and Bekure, 1991). However, even proponents of privatization of animal health systems recognize that there must be a balance between the public and private sectors (Umali et al., 1992). The public sector will have to continue with monitoring of animal health situations, as well as controlling certain epidemic diseases (c.f., Group I, Table 3). Further, both African governments and donors must continue to fund research into new technologies to prevent, control and treat livestock diseases found in Africa. Based on my personal experience, the large pharmaceutical companies consider Africa such a small and poor market that they are rarely willing to invest very much in animal health technologies specific to Africa. The African market is treated as a residual purchaser of products produced for the developed countries, which can finance the investments.

In developing alternative systems for delivering animal health care, both governments and donors must be willing to experiment with new approaches. One example is the possibility of technicians, or community based systems (e.g., Grandin, 1994). Such approaches differ quite radically from the developed country system of requiring that animal health technologies, especially drugs, be delivered by college graduates. Because of this difference, resistance to new approaches has already occurred (e.g., Grandin, 1994). Thus, donors and governments

must view such changes as long term projects, with the key to sustainability being acceptance by the farmers.

Strategic issue: funding and research institutions. Eicher (1990) characterized the present system of project by project and country by country approach to building African scientific capacity as being seriously flawed. This is because such an approach is nonsustainable, with research initiatives often withering after donor commitment is withdrawn. In terms of livestock research, very few post independent countries in Africa have had a successful long term record (c.f., Box 1). Zimbabwe is one of the few examples where livestock research has, albeit almost exclusively orientated toward cattle, received a relatively high priority from the government. The reason for this is a mixture of the political influence of large-scale ranchers, and the perceived importance of beef exports (see earlier). One general lesson from the research experience of the colonial period in Africa (1930–59) was that small, commodity orientated research teams can be very effective. Another lesson is that regional research, readily borrowing other technologies, can be productive (Eicher, 1990).

Given the dearth of relevant research (c.f., Box 1), actual research agendas and priorities for livestock is a relatively quick paper exercise. The key to enacting those agendas is to assemble small, multi disciplinary teams, reflecting the multiple roles of livestock. The role of governments, donors and scientists is to commit resources and time to those teams. The appropriate length of commitment is ten years or more. Thus, it is not so much a question of what to research, but who and how. Once a core team and set of minimum research targets has been formed and funded, additional funding for specific projects can be sought.

Strategic issue; collaboration. Given the limited resources available for livestock research, donors and governments should focus on encouraging true regional collaboration. Differences in culture (including the use of livestock) and levels of resources suggest that collaboration may work best in Africa at a regional level. Such regional collaboration would involve a network of national agricultural research stations or systems (NARS). Winrock International (1992, p. 83) outline 5 potential regional affiliations for collaboration in research (Appendix A). Regional collaborative groups then offer opportunities for international centers, such as the International Livestock Center for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD),[13] and overseas research institutes (e.g., universities) to maximize collaboration on, and dissemination of, basic research. This will allow the NARS, in a regional collaboration, to focus on what they historically have done best: applied research.

Collaboration: initial goals. The concept of improving collaboration is not new. The Special Program for African Agricultural Research (SPAAR) was established in 1985 with one of its main objectives to foster increased collaboration (Winrock International, 1992). However, by

[13]IICA and ILRAD are due integrate into a single research facility. At the time of writing, the exact details of how such an integrated unit will operate is not common knowledge.

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being established in the World Bank, it may be to remote to respond to the immediacy of livestock research within a group of NARS. It would be best if the collaborative hub be established within a region. Initial goals for a regional collaborative effort include: (1) Identify a core, multi disciplinary team which would be supported over 10 or more years; and, (2) establish an effective communications network between the team members, NARS research laboratories, appropriate government ministries and donor agencies. To be sustainable, simplicity is the key. The goal of such a collaborative arrangement should not be to hold ever bigger and larger workshops and conferences.

Some initial projects for the communications network could be to establish a simple newsletter that would be published on a frequent basis, and circulated among researchers and government and donor agencies. Also, a directory of researchers and a list of current research projects shuld prove to be a useful stimulus for maintaining connections. ILCA could collaborate by helping with a library and documentation system, often a weak point for many NARS. Finally, donors could supply some simple communications equipment, such as copiers, computers fax machines and systems for electronic mail (where possible).

Research: general issues. Research on livestock should focus on systems. For example draught power research should consider consumption of residues, implements for ploughing and cultivating, agroclimatic conditions and socioeconomic conditions that will encourage or discourage adoption. The GFA study (1987), by presenting four packages for improving small-scale livestock production in Zimbabwe, is an example of a systems approach. These packages are: (1) draught power; (2) dairy production; (3) beef production; and (4) goat meat production. For draught power, the need to improve the condition of draught animals at the beginning of the rainy season was identified as the biggest constraint. Recognizing that supplemental feeding was unlikely to be adopted (c.f., McIntire et al., 1992), the report stresses the need to set up locally managed grazing schemes which restrict access to some common grazing areas, and regulate the management of such areas (see stocking rates and feed, below). Thus, stocking rates and management of common resources, which positively impact upon the chances of sustainability, become one of the most important foci of the draught package.

Research: breeding. Genetic research should always have its priorities defined by the systems approach. For example, cross breeding for increased milk production will be viable if other elements exist for its successful adoption (e.g., access to markets). Some broad based objectives can be defined, allowing for modifications to suit local conditions. In cattle, increased milk production and more efficient (e.g., rapid) rate of gain are probably some of the most important criteria. For small ruminants, increased rates of twining and milk production, and the cross breeding for dual purpose animals are important criteria. In the case of poultry, the lack of research in Africa (c.f., Box 1) means that almost any breeding research would be of some value. However, obvious targets include improving the feed efficiency of local breeds, and use of cross breeds to increase egg production.

Dissemination of genetic research. One particular problem with breeding programs is how to

disseminate the results in an equitable manner. Improved breeds that stay on research farms, or are given to few local farmers will not do much to increase productivity. In cattle, the long breeding cycle makes adoption a slow process. For example, there are about 7.35 million trypanotolerent cattle in tsetse fly areas of Africa. Using conventional breeding strategies, it would take 15 years to double that number, which would still be less than 10 percent of the total herd in the tsetse infested area (Williams et al., 1993). To speed up and improve the results of the breeding process, others have advocated the use of sophisticated molecular genetics (e.g., Winrock International, 1992). However, since it might take 10- 20 years to perfect techniques (Winrock International, 1992) and raise a small herd of improved animals on a research station, the dilemma of rapid dissemination may not be solved. For ease of dissemination, plus equitable distribution among genders, poultry breeding research holds a promise that is yet to be explored in Africa.

Research: draught power. Issues associated with the successful and sustainable use of draught power include access to both land and markets, availability of labor, intensification of production, and the availability of cash to finance the investment (including off farm income).

To be successful, animal traction should be able to generate sufficient cash flow to pay for itself. The one area where this is most likely to occur is the use of draught power in cash crops such as cotton, rice and groundnuts (McIntire et al., 1992). Because the marginal return on feeding draft animals is often lower than feeding for meat or milk, supplementary feeding of draught animals is unlikely to be widely adopted (McIntire et al., 1992). McIntire et al. (1992) also observed that, to date, research in Africa on animal traction has had little impact on adoption rates. One reason for such failure might be that too much emphasis has been placed on simultaneous adoption of biological and mechanical technologies (Pingali et al., 1987). For example, the use of chemical fertilizers is not pre conditioned by the use of draught power. Also, some combinations of biological and mechanical technologies might increase labor requirements, which may not be available in some areas (c.f., population densities).

In summary, the adoption of animal traction as a means to increase crop production in a sustainable manner very much depends upon local conditions. It is therefore not recommended that draught power be made the sole or central emphasis of livestock related projects and policies (McIntire et al., 1992; Pingali et al., 1987). However, it should not be forgotten, and the conditions under which it may prove profitable to adopt should be studied further (i.e., what factors should case-by-case studies examine?). Draught power might well become prove to be an important component of other projects designed to intensify agricultural production.

Research: feed supply and stocking rates. In the near future, supplementary feeding of livestock may only be economically justified in specialized circumstances, such as small-scale dairy farms in highland regions. As discussed earlier, increased human livestock populations and densities have caused degradations in grazing lands (e.g., Meltzer and Hastings, 1992). History has taught us that forced destocking campaigns are not politically possible, and they are inherently unfair. The non sustainability of many grazing improvement projects through

out Africa also suggests that communities do not rapidly adjust to increases in population pressures. This has caused some to call for institutional changes in the ownership of communal lands. In Africa, however, reforms and changes in land tenure have also not been very successful. The solution to the problem is difficult, but one potential solution is the formation of community controlled grazing schemes. This idea is not new, but the introduction of schemes is fraught with technical and social problems (e.g., Cousins, 1988; Scoones, 1987; Cousins, 1987; Dankwerts, 1974). The only reason to continue this line of research and extension is the fact that such schemes offer the chance of a bottom up, and hopefully sustainable, approach to improved grazing. Governments and donors can play a role by providing technical advice, offering to be impartial mediators, and providing funding for infrastructure (e.g., fences, watering points).

Research: animal health. Governments and donors must recognize that, because private industry is unlikely to participate in a meaningful manner, they must increase funding for research on new disease control and prevention technologies. Some of this research may include investigation of new systems to deliver existing technologies in a more sustainable manner. For example, the use of economic damage thresholds and the management of tick populations promises to reduce the cost of controlling the tick-borne diseases such as heartwater (Meltzer et al., 1994, Meltzer and Norval, 1993). Any research on new animal health technologies should include a component that considers how such technologies should be delivered (see veterinary services, above). Priorities for research should be formed by considering the economic impact and the epidemiology of candidate diseases (c.f., Table 3).

Research: funding for microenterprises. The multiple outputs produced by livestock can be adapted to increase production and employment by stimulating micro enterprises. Some examples include; egg production; goat and cow milk; goat fattening; customized draught power; and, cattle fattening. However, the methods used to finance and encourage farmers to adopt such schemes need to be carefully researched, focusing on different production systems in different regions. Providing seed money for such schemes could provide donors with specific time-limited projects. Such micro enterprise schemes might also provide some specific agenda items for the long term, multi disciplinary research teams (see above).

Research: value added. To compliment any growth in micro enterprises, the feasibility of adding value to livestock products should be researched. Value added schemes could include relatively simple processing to produce cheese, powdered milk, yoghurt, and powdered eggs. Obviously, to produce such products would require much larger capital investments that envisioned for the micro enterprises. However, such capital investments may prove the key to ensuring the success of the micro enterprises. Access to markets has already been identified as key component to ensuring the sustainability of any livestock enterprise. Research would include feasibility studies, market analysis (including export potential), and an examination of appropriate technologies.

Research: marketing information. As part of the continuing efforts to liberalize the markets for livestock products, governments and donors should actively support the dissemination of

market information (a public good). Something as simple as regularly publishing prices from several markets in the local newspapers can have a positive effect, and may help to reduce variations in producer and consumer prices. Such an activity would support micro enterprises and value added activities.

Conclusions

To answer the questions posed in the introduction: Livestock can be used to improve the nutritional status of the growing human population by being incorporated into crop productions systems. Improvements in the output of animal proteins depend on changes in a number of factors, such as population density, access to markets, agroclimatic conditions and the availability of relevant technologies (i.e., research).

Livestock production can contribute to economic growth. At the moment, a large portion of livestock's contribution to growth is "hidden" in multiple roles, such as inputs into crop production (e.g., draught, manure). Increasing the production and commercialization of livestock products will be very dependent on localized conditions. Promotion of micro enterprises producing and marketing livestock products probably needs to be conducted within individual countries, on an area by area approach.

The sustainability of new livestock production systems will depend upon how successfully such systems integrate the multiple uses of livestock. To date, public institutions in Africa have done a very poor job of such integration. Typically, public institutions have focused almost exclusively on beef production. This focus has often caused distortions in livestock production. It has also marginalized the majority of livestock owners in two important ways; (1) it ignores those who do not keep livestock primarily for beef production (c.f., Table 1); and (2) it ignores other livestock, such as small ruminants and poultry. The marginalization extends beyond market interference to research and extension. Compared to cattle, small ruminants receive little research and poultry are pathetically under researched (c.f., Box 1). Thus, the sustainability of different livestock systems for small ruminants and poultry has rarely been examined or tested.

Sustainable increase in livestock productivity will only occur if innovations closely match local sets of circumstances. It is no good, for example, advocating dairy production in a particular area if there is no easy access to a urban or peri urban market. The key to defining and researching sustainable technological improvements is the formation of small multi disciplinary teams. Given the long term nature of livestock production, governments, donors and scientists should commit to supporting these teams for at least 10 years. The paper outlined several research topics that such teams could investigate. One potential method to improve the chances of producing relevant research results is to foster collaboration. Given the wide diversity of livestock systems throughout africa, it is suggested that such collaboration be organized at a regional level (e.g., Appendix A).

References

Adesina, A.A., 1992. Oxen cultivation in semi-arid west Africa: Profitability analysis in Mali. Agricultural Systems, 38:131–47.

Bailey, C.R., 1982. Cattle husbandry in the communal areas of eastern Botswana. Ph.D. dissertation, Cornell University.

Barrett, J.C., 1989. Valuing animal draught in agropastoral farming systems in Zimbabwe. Paper presented at the proceedings of a workshop entitled "Tillage, past and future, held at the Institute of Agricultural Engineering, Harare, November 14–15, 1989.

Behnke, R.H. and Scoones, I., 1992. Rethinking range ecology: Implications for rangeland management in Africa. Environment Working Paper No. 53, Environment Department, The World Bank, Washington, d.C., pp. 31.

Boserup, E., 1965. The conditions of agricultural growth: the economics of agrarian change under population pressure. Aldine Publishing Company, New York.

Bratton, M., 1984. Draft power, draft exchange and farmer organizations. Working paper No. 9/84, Dept. of Land Management, U. of Zimbabwe.

Brumby, P.J. and Trail, J.C.M., 1986. Animal breeding and productivity studies in Africa. ILCA Bulletin, January 23, 1986: 23–27.

Cossins, N.J. and Upton, M., 1987. The Borana pastoral system of southern Ethiopia. Agricultural Systems, 25:199–218.

Coughenour, M.B., Ellis, J.E., Swift, D.M., Coppock, D.L., Galvin, K., McCabe, J.T. and Hart, T.C., 1985. Energy extraction and use in a nomadic pastoral ecosystem. Science, 230(4726):619–25.

Cousins, B., 1988. Evaluation of pilot cattle grazing schemes. Unpublished report for the Department of Agricultural, Technical and Extension Services and the Commission of the European Communities, Harare, pp. 162.

Cousins, B., 1987. A survey of current grazing schemes in the communal lands of Zimbabwe. Monograph, Centre for Applied Social Sciences, University of Zimbabwe, Harare, pp. 96.

Dahl, G. and Hjort, A., 1976. Having herds. Dept. of Social Anthropology, University of Stockholm, Stockholm.

Dankwerts, J.P., 1974. A socioeconomic study of veld management in the tribal areas of the Victoria province. Dept. of Agriculture, U. of Rhodesia, pp. 147.

de Haan, C. and Bekure, S., 1991. Animal health services in sub-saharan Africa: Initial experiences with alternative approaches. World Bank Technical Paper No. 134, The World Bank, Washington, D.C., pp. 49.

Delgado, C. and McIntire, J., 1982. Constraints on oxen cultivation in the Sahel. American Journal of Agricultural Economics, 64:188–97.

Dransfield, R.D., Williams, B.G., and Brightwell, R., 1991. Control of tsetse flies and trypanosomiasis: myth or reality? Parasitology Today, 7(10):287–91.

Due, J.M., and Magayane, F., 1990. Changes needed in agricultural policy for female-headed farm families in tropical Africa. Agricultural Economics, 4:239–53.

The Economist, 1994. A flicker of light. March 5, pp. 21–24.

The Economist, 1993. Fat of the land. May 16, p. 16.

Eicher, C.K., 1990. Building African scientific capacity for agricultural development. Agricultural Economics, 4:117–43.

Eicher, C.K. and Baker, D.C., 1982. Research on agricultural development in sub-saharan Africa: a critical survey. Michigan State University International Development Paper No. 1, Department of Agricultural Economics, Michigan State University, East Lansing, pp. 335.

FAO, 1991. Animal health yearbook, 1990; No. 30. FAO, Rome, pp. 297.

FAO, 1993. Production yearbook, 1992: Vol. 45. FAO, Rome, pp. 346.

FAO, 1990. Production yearbook, 1989: Vol. 43. FAO, Rome, pp. 346.

FAO, 1991. Trade yearbook, 1990: Vol. 44. FAO, Rome, pp. 379.

FAO, 1981. Trade yearbook, 1980: Vol. 34. FAO, Rome, pp. 359.

The Farmer, 1993. Agri index. January 7, p. 6.

Fowler, M., 1981. Overgrazing in Swaziland? A review of the technical efficiency of the Swaziland herd. Pastoral Network Paper No. 12., Agricultural Administration Unit, Overseas Development Institute, London, pp. 16.

Francis, P.A., 1988. Ox draught power and agricultural transformation in northern Zambia. Agricultural Systems, 27:35–49.

Gambiza, J. Mapinagire, S., Mazaiwara, H., Moyo, N., Mugari, S. and Wood, F., 1987. Aspects of the traditional and spiritual role of cattle in Masvingo province. Department of Agricultural, Technical and Extension Services (Agritex), Harare, pp. 26.

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Gammon, D.M., 1983. Veld management: stocking rate and drought considerations. Zimbabwe Agricultural Journal, 80(5):183–85.

Gesellschaft fur Agrarprojekte in Ubersee (GFA), 1987. Study on the economic and social determinants of livestock production in the communal areas—Zimbabwe; Final report. Unpublished report prepared by GFA for the Depart. of Veterinary Services, Ministry of Lands, Agriculture and Rural Settlements, Zimbabwe, pp. 177.

Grandin, B.E., 1994. Designing community-based animal health (CBAH) training programs: approaches and dilemmas in Kenya. In press, Agriculture and Human Values.

Haggblade, S. and Hazell, P., 1989. Agricultural technology and farm—nonfarm growth linkages. Agricultural Economics, 3:345–64.

Hart, R.H., 1972. Forage yield, stocking rate, and beef gains on pasture. Herbage Abstracts, 42(4):345–53.

Jaeger, W.K., and Matlon, P.J., 1990. Utilization, profitability, and the adoption of animal draft power in west Africa. American Journal of Agricultural Economics, 72(1):35–48.

King, J.M., Sayers, A.R., Peacock, C.P. and Kontrohr, E., 1984. Maasai herd and flock structures in relation to livestock wealth, climate and development. Agricultural Systems, 13:21–56.

Koen, C., 1987. Optimal stocking rates for several species-farming. Agricultural Systems, 23:159–66.

Konandreas, P.A., Anderson, F.M., and Trail, J.C.M., 1983. Economic trade-offs between milk and meat production under various supplementation levels in Botswana. International Livestock Centre for Africa (ILCA) Research Report No. 10, ILCA, Addis Ababa, pp. 52.

Konczacki, Z.A., 1978. The economics of pastoralism. Frank Cass, London.

Knols, B.G.J., Willemse, L., Flint, S. and Mate, A., 1993. A trial to control the tsetse fly, *Glossina morsitans centralis*, with low densities of odor-baited targets in west Zambia. Medical and Veterinary Entomology, 7:161–69.

Lawrence, J.A., Foggin, C.M., and Norval, R.A.I., 1980. The effects of war on the control of diseases of livestock in Rhodesia (Zimbabwe). Veterinary Record 7:82–85.

Lele, U. and Stone, S.W., 1989. Population pressure, the environment, and agricultural intensification: variations on the Boserup hypothesis. MADIA discussion paper No. 4. World Bank, Washington, D.C., pp. 79.

Le Roux, P., Stubbs, A.T., and Donnelly, P.H., 1978. Problems and prospects of increasing beef production in the Tribal Trust Lands. Zambezia, 6(1):37–52.

Lipner, M.E. and Brown, R.B., 1994. Constraints to the integration of the CCPP vaccine into Kenya's animal health delivery system. In press, Agricultural and Human Values.

Matthewman, R.W. and Perry, B.D., 1985. Measuring the benefits of disease control: relationships between herd structure, productivity and health. Tropical Animal Health and Production, 17:39–51.

McIntire, J., Bourzat, D. and Pingali, P., 1992. Crop-livestock interaction in sub-saharan Africa. World Bank, Washington, D.C., pp. 246.

Meltzer, M.I., 1990. Livestock biotechnology: The economic and ecological impact of alternatives for controlling ticks and tick-borne diseases in Africa. Ph.D. dissertation, Cornell University, pp. 594.

Meltzer, M.I. and Hastings, H.M., 1992. The use of fractals to assess the ecological impact of increased cattle population: case study from the Runde communal land, Zimbabwe. Journal of Applied Ecology, 29:635–46.

Meltzer, M.I., Norval, R.A.I, and Donachie, P.L., 1994. The effects of tick infestation and tick-borne disease infections (heartwater, anaplasmosis and babesiosis) on the lactation and weight gain of Mashona cattle in southeastern-Zimbabwe. In press, Tropical Animal Health and Production.

Meltzer, M.I., and Norval, R.A.I., 1993. Evaluating the economic damage threshold for bont tick (*Amblyomma hebraeum*) control in Zimbabwe. Experimental and Applied Acarology, 17:171–85.

Mtetwa, R.M.G., 1978. Myth or reality: The "cattle complex" in south east Africa, with special reference to Rhodesia. Zambezia, 6(1):23–35.

Mukhebi, A.W., Perry, B.D. and Kruska, R., 1992. estimated economics of theileriosis control in Africa. Preventive Veterinary Medicine, 12:73–85.

Murray, M., Morrison, W.I., and Whitlow, D.D., 1982. Host susceptibility to African trypanosomiasis: trypanotolerance. In: Baker, J.R. and Miller, R. (eds). Advances in Parasitology, v.21. Academic Press, London.

Norval, R.A.I., Sonenshine, D. E., Meltzer, M.I., Burridge, M.J., and Yunker, C., 1994. Attractant decoy for controlling bont ticks. United States patent No. 5,296,227.

Nuru, S. and Buvanendran, V., 1985. The indigenous breeds of Nigeria: problems and potential. In: Copland, J.W. (ed). Evaluation of large ruminants for the tropics. Proceedings of an international workshop held at CISRO, Rockhampton, Queensland, Australia, ACIAR Proceedings Series No. 5, pp. 178.

Pingali, P., Bigot, Y. and Binswanger, H.P., 1987. Agricultural mechanization and the evolution of farming systems in sub-saharan Africa. World Bank and Johns Hopkins University Press, Baltimore, pp. 216.

Sanford, S., 1987? Crop residue/livestock relationships. Paper presented at a workshop on soil, water and crop management systems for rainfed agriculture in the Sudano-Sahelian zone. Date and place of workshop unknown.

Sanford, S., 1982. Livestock in the communal areas of Zimbabwe. A report prepared for the Ministry of Lands, resettlement and Rural Development. Unpublished report, Overseas Development Institute, London, pp. 169.

Sarma, J.S. and Yeung, P., 1985. Livestock products in the third world: past trends and projections to 1990 and 2000. Research report No. 49. International Food Policy Research Institute (IFPRI), Washington, D.C., pp. 87.

Savadago, K., Reardon, T., and Pietola, K., 1994. Farm productivity in Burkina Faso: Effects of animal traction and nonfarm income. American journal of Agricultural Economics, 76(3);608–12.

Scoones, I., 1992. The economic value of livestock in the communal areas of southern Zimbabwe. Agricultural Systems, 39:339–59.

Scoones, I., 1987. Economic and ecological carrying capacity: Implications for livestock development in the dryland communal areas of Zimbabwe. Unpublished paper presented at the University of Zimbabwe, 24 September, 1987.

Shanmugaratnam, N., Vedeld, T., Mossige, A., and Bovin, M., 1992. Resource management and pastoral institution building in the west African sahel. World Bank Discussion Papers No. 175, Africa Technical Department Series, The World Bank, Washington D.C., pp. 77.

Shumba, E.M., 1985. On-farm research priorities resulting from a diagnosis of the farming systems in Mangwende, a high potential area in Zimbabwe. Special report No.5, Zimbabwe Agricultural Journal, pp. 79.

Simpson, J.R. and Sullivan, G.M., 1984. Planning for institutional change in utilization of sub-saharan Africa's common property range resources. African Studies Review, 27(4):61–78.

Steele, M.C., 1981. The economic function of African owned cattle in colonial Zimbabwe. Zambezia, 9(1):29–48.

Sullivan, G.M., Farris, D.E., Yetley, M.J. and Njukia, W.J., 1978. A socio-economic analysis of technology adoption in an African livestock industry. Zeitschrift fur austlandische Landwirtschaft (J. for foreign agriculture), 2:150–59.

Tawonezvi, H.P.R., 1989. Growth of Mashona cattle on range in Zimbabwe. II. Estimates of genetic parameters and predicted response to selection. Tropical Animal Health and Production, 21:170–74.

Theisen, R.J., and Marasha, J., 1974. Livestock in the Que Que tribal trust land: an ecological study of the importance of livestock to development. Unpublished report for the Ministry of Agriculture, Government of Rhodesia. pp. 26.

Turk, J., 1984. An assessment of animal health projects: U.S. Agency for International Development, 1960–1993. In press, Agricultural and Human Values.

Umali, D.L., Feder, G., and de Haan, C., 1992. The balance between public and private sector activities in the delivery of livestock services. World Bank Discussion Paper No. 163, The World Bank, pp. 114.

Walsh, J., 1986. War on cattle disease divides the troops. Science, 237:1289–91.

Webster, C.C. and Wilson, P.N., 1980. Agriculture in the tropics. Second edition. Longman, London, pp. 640.

Wieblet, M., 1992. The sectoral incidence of protection and Zimbabwean agriculture. Journal of Agricultural Economics, 43(2):205–17.

Williams, B., Dransfield, R., Brightwell, R., and Rodgers, D., 1993. Where are we now? Trypanosomiasis. Health Policy and Planning, 8(1):85–93.

Williams, T.O., 1993. Livestock pricing policy in sub-Saharan Africa: objectives, instruments and impact in five countries. Agricultural economics, 8:139–59.

Wilson, R.T., 1986. Livestock production in central Mali: Long-term studies on cattle and small ruminants in the agropastoral system. Research report No. 14, International Livestock Centre for Africa (ILCA), Addis Ababa, pp. 111.

Winrock International, 1992. Assessment of animal agriculture in sub-saharan Africa. Winrock International, Morrilton, Arkansas, pp. 125.

World Bank, 1993. World development report, 1993: Investing in Health. The World Bank, Washington, D.C., pp. 329.

World Bank, 1989. sub-Saharan Africa: From sustainable crisis to sustainable growth. The World Bank, Washington, D.C. pp. 300.

Yilma, T.D., 1989. Prospects for the total eradication of rinderpest. Vaccine, 7:484–85.

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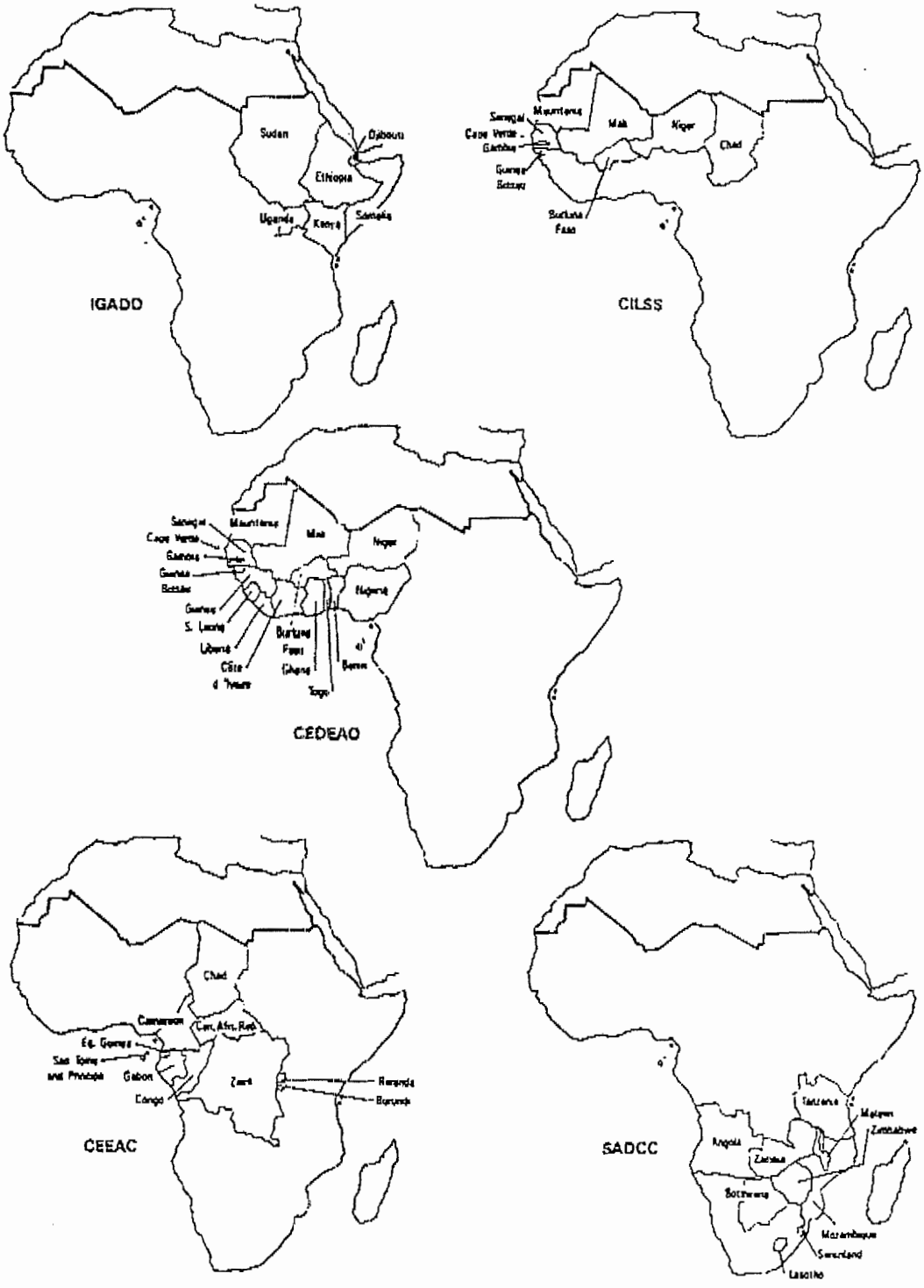
Appendix A: Potential regional affiliations for collaboration in agricultural research



Source: Winrock International, 1992

Appendix B: Probable increases in production and elasticities of demand

Probable increases in production

When considering probable, or even possible, increases in livestock productivity in Africa, the core concept is that of interaction between genotype and environment. Theoretically, improvements in either genotype or environment or both will increase productivity. Unfortunately, animal breeding and productivity studies in Africa are scarce. A comprehensive review of cattle breeding studies in Africa between 1949 and 1978 listed only 500 papers, of which only 20 percent contained comparative data on two or more breeds. Further, only 5 percent of those papers provided sufficient evidence to allow comparisons between breeds based on productivity indices (Trail, 1981, as reported in Brumby and Trail, 1986). Within the constraints of the limited data, given below are some estimates of the increased productivity that can be expected for three interventions; (a) environment/production systems; (b) cross breeding for liveweight gain; and, (c) cross breeding to increase milk production.

Environment/production system

From Table 2 in the main body of the paper, it can be seen that management systems can have a marked effect on productivity. For example, indigenous cattle raised on ranches can have an average calving rate that is 60 percent higher than the traditional systems (80 percent vs. 50 percent). Further, weights at birth, weaning, two years and four years are all markedly higher under a ranch system of management. The average weight at four years of age under ranch management was 45 percent greater than under traditional management (363 kg vs. 250 kg). There are many reasons for such differences, but one of the most important reasons is the quantity and quality of available forage over time. Although pastoralist systems have been characterized as being very efficient users of the ecosystem (cf. section "Pastoralist herds and multiple roles"), traditional production systems rarely provide supplemental feed during the dry winter months, and milk offtake for human consumption may stunt the growth of calves.

Relatively small changes in management can cause noticeable increases. The GFA study (1987) proposed an improved beef production package for Zimbabwe's communal lands, which included the introduction of the use of crop residues, legume stover, and treatment of maize stover with molasses or urea or both. The legume stover would be produced through intercropping maize with beans or groundnuts. Without changing any other management practices, or the genotypes used, these interventions were anticipated to increase the calving rate from 44 percent to 55 percent, the offtake rate from 5.17 percent to 7.82 percent and the weighted average carcass weight from 177 kg to 187 kg. The combined effect of these increases would be to increase beef output by 59 percent.

Small increases in availability of nutrients can sometimes have a marked impact. Ward (1968) found that feeding indigenous Mashona cattle a bone meal and salt lick *ad libitum* (mean daily intake was 3.7 ounces) increased calving weight by 21 percent. Compared to control

animals, cattle receiving groundnut cake (a more expensive proposition), almost doubled conception rates (76 percent vs. 38 percent). The treated cattle were also about 100 lbs heavier during lactation, and their calves were 38 percent heavier at weaning.

Improved feeding can also significantly increase milk yields. Smith et al. (1991) fed sanga cow-calf units for 13 weeks, at the beginning of lactation, on maize stover and legume residues for about three hours per day, plus gave 1 kg/cow/day of maize bran and maize silage at night. Further, urea mineral licks were made available at the rate of 250-300 g/cow/day. This simple feeding program resulted in an 86 percent increase in calf average daily gain (253 g vs 136 g), a 79 percent increase in daily milk offtake (893 ml vs. 498 ml), an 86 percent increase in total daily milk yields (3.41 l vs. 1.83 l), and a 23 percent increase in dam weight over 13 weeks (+0.91 kg vs. -20.0 kg). Overall the supplemented cows produced an additional 27 l per cow over 13 weeks.

Changes in management that can improve the quantity and quality of available forage include practices which alter the utilization of the natural resource base. For example, locally managed grazing schemes which limit access to a defined grazing area will seek to improve the amount of forage available to each animal. With regard to small ruminants, the same levels of increased outputs can be expected due to improved quantity and quality of forage (e.g., GFA, 1987).

Cross-breeding for liveweight gain

Cross-breeding to improve liveweight gain is unlikely to bring substantial benefits. Tawonezvi et al. (1988a, 1988b) compared the productivity of three breeds indigenous to Zimbabwe, one sanga breed, and three exotic breeds, plus 16 crossbreeds. It was concluded that none of the crossbred cattle were any more productive than the indigenous Mashona in terms of weight of weaned calf per 100 kg of cow per year. The author's concluded "There is therefore no advantage in using crossbred cows where more productive [indigenous] purebreds are available, especially when the superiority of a highly productive cross may be offset by the cost of maintaining inferior parents to produce the cross." This does not mean that all beef breeding programs are not viable. Rather, it means that beef breeding programs should include improved purebreed indigenous cattle.

Cross-breeding for increased milk production

Substantial gains can be obtained from cross-breeding indigenous cattle (and goat) breeds with exotic (e.g., *Bos taurus*) breeds. Essentially, indigenous zebu (*Bos indicus*) and sanga cattle have a very low genetic potential to produce milk. Crossbreed cattle will produce 50 percent-75 percent more milk than purebreed indigenous species. For example, pure bred Tswana cattle can produce up to 1,900 kg per lactation (5–8 yrs, maximum yield), while Tswana x Simmental can produce 3,500 kg per lactation (Konandreas et al., 1983). The data in Table B.1 can be used to assess the potential gains from crossbreeding.

Table B.1 : Increase in milk yields due to crossbreeding

Livestock type	Mean lactation yield (kg)	Mean liveweight (kg)	Yield(kg)/10kg liveweight
Goat			
Tropical	200	40	50
European crossbred	400	50	80
European purebred	600	60	100
Cow			
Unimproved zebu	400	300	13
Improved zebu	1,000	350	29
European crossbred	2,000	400	50

SOURCE: Webster and Wilson.

The key to ensuring that such increases are actually realized is the supply of an adequate diet (cf. "Environment/production system"). Also, it must be recognized that there are limits to the proportion of exotic genes that should be used in crossbreeding programs. For example, once the proportion of crossbred cows reaches 75 percent *B. taurus*, calving intervals will probably lengthen and overall productivity decline (Webster and Wilson, 1980). This is due to heat and other environmental stresses.

Elasticities of demand

There are only a few studies which estimated demand and supply elasticities for livestock products in Africa. These are reviewed in Williams (1993) and Winrock International (1992), and presented in Table B.2. Extreme caution should be taken when using these estimates. Many of the estimates were calculated using data from the 1960's through to the early 1980's. This was a period when many agricultural products in Africa received consumer and, sometimes, producer subsidies. Thus, demand could be distorted by artificially low prices.

Table B.2: Elasticities of supply, demand and income

Elasticity	Estimates	
	Low	High
Long-run supply (price)		
Beef	0.3	1.0
Mutton	0.5	1.25
Milk	0.6	1.50
Long-run demand (price)		
Beef	-0.5	-1.05
Mutton	-0.6	-1.25
Milk	-0.66	-1.2
Income demand		
Meat	0.79	0.98
Milk	0.68	0.82
Eggs	1.05	1.10
Cereals	0.20	0.22

SOURCES: Williams, 1993; Winrock International, 1992.

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Additional references

Smith, R., Pegram, R.G., Burt, S., Killorn, K.J., Oosterwijk, G., Patterson, A. and Wilsmore, A.J., 1991. Effect of dry season supplementation of sanga cattle in Zambia. Tropical Animal Health and Production, 23:103–5.

Trail, J.C.M., 1981. Merits and demerits of importing exotic cattle compared with improvements of local breeds. In: Intensive animal production in developing countries. Occasional publication No. 4, British Society of Animal Production; cited in; Brumby, P.J. and Trail, J.C.M., 1986. Animal breeding and productivity studies in Africa. ILCA Bulletin, January 23, 1986: 23–27.

Tawonezvi, H.P.R., Ward, H.K., Trail, J.C.M. and Light, D., 1988a. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 1. Productivity of purebred cows. Animal Production, 47:351–59.

———, 1988b. Evaluation of beef breeds for rangeland weaner production in Zimbabwe. 2. Productivity of crossbred cows and heterosis estimates. Animal Production, 47:361–7.

Ward, 1968. Supplementation of beef cows grazing on veld. Rhodesian Journal of Agricultural Research, 6:93-101.

Agricultural research and technology innovation in Africa: organizational and financial concerns

by

Donald L. Plucknett

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Part 1. The case for effective agricultural research in Africa

> "No country has achieved substantial agricultural development without establishing and maintaining efficient governmental experiment stations for agricultural research." A. T. Mosher, *Getting Agriculture Moving,* 1966.

We are nearing the end of a historic century of agricultural change that fueled tremendous economic and social change around the world. Such change could not have resulted without the great improvements brought about by scientific agriculture that took place in North America, South America, Europe, Oceania and Asia. But Africa has not benefited as much as the others. Will the dismal performance of agriculture in many African countries continue? Is Africa doomed to poor economic performance and continuing poverty for its population? What can be done to help Africa climb out of its pit of poverty and move ahead in developing its agriculture and food production systems? This paper will discuss the potential role of agricultural research in Africa, its management and financial support.

The imperative for improvement in African agriculture

> "The only pathway for agricultural and economic advance open to most developing countries is the continuous increase in productivity of their land and water resources without detriment to the long-term production potential of the country's natural resources." J.C. Madamba, 1985.

Africa cannot continue to neglect agriculture and fail to lay the groundwork for its improvement. If it does, misery, hunger, and environmental degradation caused by poverty will continue. A study by FAO (1984) probably says it best: "By the end of this century, the entire lands of developing coulltries—almost three times the present cultivated area--would barely be sufficient to feed their expected populations if traditional methods of farming continued to be used. No less than 64 countries—29 of them in Africa—would be unable to feed their projected population from their own land resources. Some 2,450 million hectares, almost two fifths of the land area, with 60 percent of the total population, would be carrying more people than they could support, representing a serious threat to human welfare and the environment."

At present, "aid fatigue" has especially serious implications for Africa, since many international donors have simply grown weary of pouring money into the continent with so little evidence of improvement.

A study of global food needs to the year 2025 conducted by the International Food Policy Research Institute (IFPRI), Washington, D.C., has a sobering, even shocking, message for Africa. This study looked at cereal production potential for Africa by the year 2025, and concluded that at present growth rates in productivity and projected improvements the

continent would then be producing in the order of 144 million metric tons (Mmt) of cereal grains. But in 2025 market demand for cereals would be 173 Mmt, with 29 Mmt of that demand being met by imports. However, the study concluded, the estimated 177 Mmt demand level calculated dealt only with current (but inadequate) daily supplies of food today, and did not deal with the "hidden demand" that would exist above current market demand. When "hidden demand" to improve diets was taken into account, the annual deficit was 125 Mmt at a daily diet of 2500 calories/day, 185 Mmt at 3000 calories/day, and 304 Mmt at 4000 calories/day. When both the hidden demand and import needs were taken into account, the total gap amounted to 154 Mmt at the 2500 calories/day dietary level, 213 Mmt at the 3000 calories/day level and 333 Mmt at the 4000 calories/day level. Finally, the study concluded that Africa must triple its production, much of it by increasing crop yields at least threefold, by the year 2025.

It is the thesis of this paper that the best place to start in improving African economies is to improve agricultural performance by establishing effective agricultural research and technology innovation systems in each country.

Agricultural research as an investment

Willis L. Peterson (1976) probably stated best the case for agricultural research: "*Agricultural research is best viewed as an investment* (emphasis added)." Real resources such as scientific personnel, laboratories and equipment, buildings, etc. are employed to produce a product or output. The output is new knowledge. New knowledge has value because it enables society to increase its total output of goods and services. In the case of agricultural research, the knowledge produced is utilized in two ways. First, it makes possible the production of new or improved inputs for agriculture. These inputs include new higher yielding varieties-of crops, more productive breeds of livestock and poultry, more efficient machines and power, and yield-increasing herbicides and insecticides. Secondly, the knowledge may be utilized directly by farmers enabling them to produce more efficiently, thereby increasing output for a given level of production cost.

"The value of agricultural research can be measured by the value of additional output that results from greater productivity in agricultural production. This additional output can be food and fiber, or it can be a greater output of nonagricultural products made possible by the release of conventional inputs from agriculture, mainly land and labor."

In this last paragraph Peterson makes the connection between agricultural growth and its positive effects on the output of nonagricultural enterprises, which of course, leads to industrialization. This message should not be lost on African leaders nor on AID administrators.

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Part 2. Some important concepts and their application to Africa

Types of research capacity that might be developed

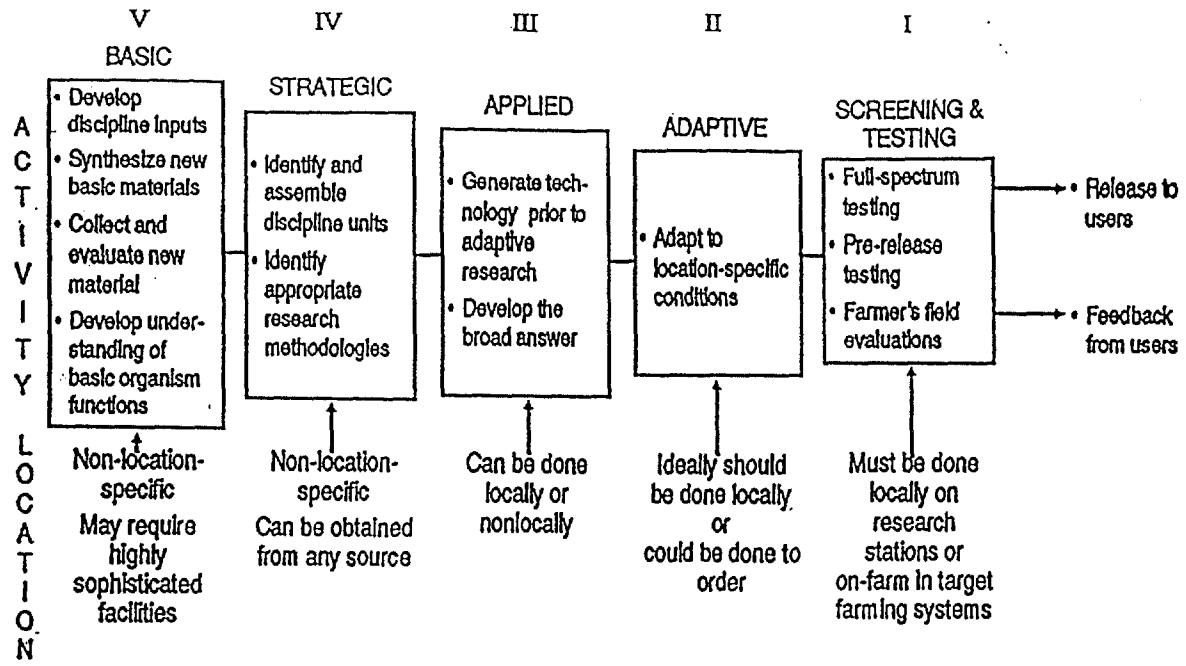
Levels or phases of agricultural research. Research can be carried out in several levels or phases, recognizing however that research is really a continuum of activity, from search for new fundamental knowledge to its eventual application and use in daily life. Recent work by ISNAR (International Service for National Agricultural Research) probably summarizes it best (see Figure 1; from Eyzaguirre, 1991).

- *Basic research* (Level V) can be defined as fundamental research aimed at understanding basic concepts and advancing the state of knowledge. Basic research is the feedstock of new ideas and concepts for advances in all fields of endeavor that benefit from science, including agriculture. However, very little true basic research is done in agriculture, since most agricultural research is aimed at overcoming specific problems and increasing options for farmers.

- *Strategic research* (Level IV) is essentially fundamental research that is aimed at overcoming specific problems. Fundamental research in agriculture is best classified as strategic research, because although the reason for the research is problem solution, without fundamental research and search for new knowledge major problems are unlikely to be overcome. Large research institutions in industrialized or middle income countries are most likely to conduct strategic research. Some smaller developing countries may decide to conduct strategic research in specific areas where problems exist and for which effective partners cannot be found, but this would be unusual.

- *Applied research* (Level III) is aimed at finding a use for new knowledge coming from strategic or basic research. Finding application for new knowledge to help improve production and farm profitability is a major activity of agricultural research, and most NARSs will aspire to conducting effective applied research so as to use scientific developments from elsewhere in improving a country's agriculture.

- *Adaptive research* (Level II) is aimed at modifying research products and ideas that result in new technologies so these can be used in location-specific situations. Adaptive research is especially useful in finding ways to extend the range of adoption of new technologies because it concentrates on the fine-tuning of management practices that may be required to make a new idea work in specific locations. Almost all NARSs should aspire to conduct effective adaptive research.



Source: Adapted from ISNAR (1981).

Figure 1. Phases of agricultural research within a global agricultural research system

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- *Screening and testing* (Level I) aims to test materials from elsewhere under local conditions for possible direct use. It requires good research technique and analytical skills to ensure its validity, but it does not require sophisticated equipment or laboratories. I believe all NARSs, as a minimum, should have the capacity to carry out effective screening and testing. An important point should be made; for countries that can identify ecological analogues of their own production conditions, a carefully-designed screening and testing system for new technology from those sources may be a cost-saving and effective agricultural research strategy.

Productivity maintenance research. There is one more category of research that should be discussed before proceeding further. As yields rise, it takes more and more research effort to maintain those yield levels, not to speak of raising them even further. The reason is that pests and diseases and other threats to crops are always changing and evolving, and new genetic materials and management practices will be required to prevent yields from falling back to the old unsatisfactory levels. This type of research has been termed 'yield-protecting,' 'yield-maintaining,' 'maintenance,' etc. and for want of a better term has been termed 'maintenance research.' (Plucknett and Smith, 1986), or preferably, 'productivity maintenance research.' Some insightful authorities recognized the need for this type of research even earlier; for example, Moseman (1970), commenting on the Green Revolution in wheat and rice, suggested both 'protective' research to maintain the momentum of existing advances in wheat and rice production and 'adaptive' research to extend it to additional growing areas were needed. Today, International agricultural research centers (IARCs) that provide a continuing flow of new genetic materials for NARSs do help to provide major inputs into productivity maintenance research for individual countries, but each NARS must provide for effective productivity maintenance research for their major commodities. Research levels I, II, III and IV may all be needed to ensure effective productivity maintenance research for a given country, but effective research at levels III and IV may be achieved through cooperation with the IARCs and developed country research institutions (DCRIs).

General categories of NARSs

In recent years there have been attempts to categorize NARSs according to their capacity to do research and the resulting role(s) they may be able to play domestically and globally. Thus AID classed countries in two categories as technology-adapting and technology producing (USAID, 1985). I have arranged my own typology of categories in a related fashion as follows, using plant breeding capability as a proxy for relative stage of development of scientific capacity:

- *Category I.* Countries that essentially do no experimentation and whose only capacity may be to serve as a generalist contact with outside research organizations. In such countries only rudimentary Screening and Testing (Level I) might be possible, after proper training of local participants, but effective linkages with researchers and research developments elsewhere will be extremely

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limited. Because of lack of capacity, Category I countries must rely on technology developed elsewhere, and have almost no capability to evaluate that technology under local conditions. Category I countries have very little chance of success to improve their agriculture.

- *Category II.* Technology-importing NARSs that do limited experimentation but are restricted mostly to Adaptive Research (Level II) and Screening and Testing (Level I and with no plant breeding capability, including plant selection. Category II countries must rely mostly on technology from elsewhere, and therefore are very dependent on others to make sound scientific choices as to direction and type of research, but do have some capacity to test and adapt those technologies, when available, to local conditions.

- *Category III.* NARSs that import technology but also carry out Screening and Testing (Level I), Adaptive Research (Level II) and some Applied Research (Level III). Some capability in selection of improved crop plants but no plant breeding.

- *Category IV.* NARSs that are effectively linked into the global technology generation system, that have plant breeding capability and can carry out research in Levels I, II and III with relative ease.

- *Category V.* NARSs that enjoy peer or near-peer relationships with IARCs and DCRIs in selected areas of research, and that are capable of carrying out Strategic Research (Level IV) in those selected areas when necessary. Effective plant breeding capability, including the ability to handle and utilize basic germplasm and advanced techniques. Category V NARSs can be full partners in helping to solve certain pressing global or continental research problems.

How much research capacity does a developing country need?

"Developing countries need strong national research capabilities to build appropriate technologies, to adapt and apply innovations to local problems and to benefit from the results of international and regional research." Edouard Saouma, Director General, FAO, 1978.

Each country is different and thus may well require a somewhat different research model from others of its size. However, each country, no matter how small, needs an agricultural research capacity that allows it to identify problems, solve important problems and provide new technologies to farmers so as to help increase farm productivity and incomes. New technologies may be borrowed from other countries and international research institutions, or they may be developed within the country itself.

Regarding agricultural research capacity, a useful analogy here might be to a capability

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compare agricultural research with human health. Each country needs in public health, in preventative medicine and in treatment of disease. Public health-deals with makers of sanitation, clean water, prevention of epidemics, immunization and so on. In cases where new health problems arise and are recognized by the public health authorities, or where more specialized medical help is needed, outside help may be needed. In the meantime, general practitioners handle most of the health care for the public at large, while major hospitals or urban centers have available those medical specialists required to handle the more difficult cases.

To carry the analogy further, agricultural research in small countries should be able to handle matters relating both to 'public health' and 'general practice'. This capability must handle problem identification and solution of the more immediately-solvable problems. As in public health and general medicine, the more difficult problems may require attention by specialists or by referral to experts outside the country.

Most African countries are quite small, with populations akin to those of smaller states of the USA. Many are poor and would probably say they cannot support a large agricultural research capability. But how large is large, and what is the minimum that may be needed?

There are two aspects to the question of how large a NARS might be. One relates to *scale of a NARS,* which refers to the size of the overall research enterprise; the other relates to *scope of a NARS* or the breadth and coverage of the research program (Eyzaguirre and Okello, 1993). Many countries make the mistake of trying to cover all possible commodities or problem areas, and thereby find themselves spread too thinly to do effective research in any one area.

The International Service for National Agricultural Research (ISNAR) recently completed a study of agricultural research in small countries; the study defined small countries as having 5 million people or less, and where agriculture is a significant contributor to gross domestic product (GDP) or employs a major share of the population (Eyzaguirre and Okello, 1993). Fifty countries around the world were selected for study, 25 of which were classed as African. Within the 50 countries, few research organizations had more than 50 researchers and most had less than 40. We will deal later with questions of recommended levels of staffing for a NARS of small countries.

Any system of agricultural research should have agricultural specialists who can monitor and measure the general trends of the nation and its agriculture, a kind of "agricultural health service." Such persons are often specialists in a particular field but have the capability to look broadly at a nation's agriculture and assess its general status, its problems and potentials, and possible future directions. Such persons should also have the capability to understand farms and farmers. There is also need for land and water specialists who can look widely at the nation's natural resource endowment and help plan for its wise use and effective utilization; these specialists constitute a kind of "natural resources health service."

More specialized scientists are usually needed to handle specific crop and livestock problems. Plant pathologists, entomologists, animal health specialists, agronomists, soil scientists, agricultural economists and agricultural engineers are core disciplines that are often required to carry out what might be termed "a crop or livestock industry health service." What is needed here again is at least a minimum number of capable persons in a discipline to identify problems, plan for their solution, and form necessary partnerships to carry out the needed work.

How many scientists does a small country need to handle the "agricultural health service" role? No fixed number can be given, of course, but probably at least three or four may be needed. For natural resource analysis and planning, the "natural resources health service," there should probably be at least one soil resource specialist and one water resource specialist, but this would provide only a very minimal capability in most countries in Africa where specialization in the natural resources of various regions or districts of a country may be needed.

In many cases, the major crops and livestock enterprises may require specialists in several fields. Hence, in a country where cassava is a major crop, a minimum-level cassava research team may require a fulltime plant pathologist, geneticist/breeder and agronomist. Also, since cassava is vegetatively propagated, one of the team should be able to do tissue culture work, at least to receive new genetic materials in tissue culture and grow them into plants. For livestock work, a minimum-level team might consist of a nutritionist/animal production specialist and an animal disease specialist. In all of the crop or livestock areas, some specialists may have to provide advice and cooperate in research with several commodity teams. Agronomists, soil scientists, plant pathologists, entomologists, and animal disease specialists are examples of specialties that are often shared across crop or livestock commodity research teams.

For most small countries where agriculture is important, and where the country wishes to generate at least some of its own technology, an effective agricultural research capacity (perhaps a Level III NARS) may require 50 to 150 scientists. However, if a country decides that for now it can only be a technology importing country (say a Level II NARS), an effective agricultural research system may require 20 to 40 scientists. Ruttan (1991) stated, "Even a relatively small country, producing a limited range of commodities under a limited range of agroclimatic conditions, will reguire a cadre of 250 to 300 agricultural scientists." In this regard, Ruttan might have had in mind at least a Level III NARS, but more likely a Level IV NARS. Eicher (1992), by contrast, states that most countries in Africa with populations below five million should aim for a NARS with 25 to 150 researchers, probably a Level III NARS in our typology. In the end, each country will have to decide for itself what the scale and scope of its research effort will be. Those decisions should be made within the context of a strategic planning process (see Part VI, Strategic Planning).

A major reference work with regard to size and capacity for research in developing countries is the ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems (Pardey and Roseboom, 1989). This book has statistical information and a description for every country in Africa and will prove useful for anyone contemplating the improvement of a NARS.

Part 3. African NARSs within a global context

The global agricultural research system

Little international cooperation in agricultural research occurred until after World War II. Before that time, most advances in agriculture were essentially "home-grown gains, involving local scientists working on problems of national importance with tools and genetic materials that were at hand" (Plucknett, 1993). It could be said at that time that most nations had to "go it alone" in agricultural research. Today, a global agricultural research system has grown and developed to the point where most scientists are, or can be if they so desire, active in the system, to the benefit of all. There is no reason for any country to go it alone in agricultural research and in efforts to improve its agriculture.

The global agricultural research system today consists of three main types of players: national agricultural research systems of developing countries (NARSs), international agricultural research centers (IARCs), and advanced institutions in developed countries (DCRIs). These players interact in a variety of ways and through various mechanisms, induding bilateral and multilateral agreements, contracts, and research networks. The system was founded on scientific and research needs. No one passed legislation calling for its formation, no one appropriated funds to ensure its establishment. With its subsequent growth and development, it can truly be said that agricultural research today is the world's largest and most collaborative scientific enterprise. Almost every country is involved in some way and has invested some of its own funds to participate. Many developing countries worry constantly about the possibility that science and technology developments will pass they by. The global system provides a means for such countries to participate in research important to them and to the world.

As an informal operation, the global system depends on goodwill and the meshing of perceived needs of numerous research organizations. Self interest is a strong motivator, and in the work of the global system there is something useful for almost every country.

International problems that need solution

Agricultural research is involved in both scientific discovery, which includes essentially five types of scientific research (Figure 1), basic, strategic, applied, adaptive, and screening and testing, all of which can result in technology innovation. Not much truly basic research is done in agriculture, because although fundamental information is needed on pressing problems, much of the work required is more properly termed strategic research, which is really basic in nature, but with a clear problem and purpose in mind. Much applied and adaptive research in agriculture is geared toward technology innovation.

Agricultural research problems fall into three main categories:

- *transnational global problems,* that usually require international solutions. These are

the really big ones, some of which are so pressing that they could be termed "21st Century Problems."

- *transnational regional problems,* that are important on a regional basis, which have not (yet) become transnational global problems. These need transnational solutions, usually through some kind of regional entities or cooperative efforts.

- *national problems:* problems that are localized and even location-specific, which in most cases must be solved at local level with local resources, unless the national system concerned can find ways to bring in outside help.

The Green Revolution in rice and wheat in Asia and Latin Arnerica that began in the late 1960s dramatized the tremendous effect that agriculture, once considered a backward and nearly hopeless sector of the economy in the poorer countries, really could have in accelerating economic growth. At that time also, agricultural research came to be seen as a means of delivering rapid, forceful change to poor countries. The Green Revolution came about as a result of problemoriented research by IRRI and CIMMYT, the first IARCs. Their success led to a new vision for agricultural research and for international cooperation in solving important problems.

The new vision for agricultural research induded a new paradigm for solving pressing agricultural problems, including new thinking on how needed research might be organized and financed. It became clear to some scientists that every nation could benefit from international agricultural research, and that developing countries, although still receiving high priority as beneficiaries, should not be considered the only clients for such research.

In this regard the following conceptual model for problem analysis, method of solution and funding sources began to emerge (Plucknett, 1994):

Type/Scope of problem	**Method of solution and funding**
Global, transnational	Multilateral
Regional, continental	Multilateral Regional, continental Bilateral aid (mostly to strengthen NARSs)
National	National Bilateral aid (mostly to strengthen NARSs)

In a way, the work on global or transnational problems in particular can be considered as providing a *supply function in research.* Here major problems constraining agriculture on a

large scale, both in magnitude and geographically, are identified and solutions are found by institutions that possess the capability and resources to carry out research, in special partnerships, on a global basis. It should be noted that regional or continental problems, such as those of Africa, can be solved much in the same way as global problems, albeit in a more limited geographic context, and also provide a kind of supply function in research.

A *demand function in research* is seen most clearly in problems that are national in scale and scope. Here a nation has a need that must be filled; the main question that must be answered is how to solve that problem. Can the problem be solved by the nation's scientists themselves? Is new germplasm from global germplasm collections needed for breeding new genetic lines? Do the IARCs or other organizations know of other countries that have encountered the same or similar problems? Are new methods or methodologies needed that will help to solve the problems? Are partners from the IARCs or from developed country laboratories needed in solving the problems? Is the problem encountered one that is likely with time to become continental or global in nature?

It should be mentioned that a *demand function in research* can also result at all levels of research, from global, through regional or continental, to national levels, but that *the demand function in research probably shows up most clearly at national level.* Examples of global problems needing solution, and associated with a high demand for research to overcome them, are major diseases of crops or animals, such as African Swine Fever or Black Sigatoka Disease of bananas or plantains, or barley yellow dwarf virus, a severe disease of cereals.

The lure of regional research institutions

Regional support has received some attention as a strategy to improve *regional research and development* efforts, but has often proved problematical. Many countries appear unwilling to provide funding for a regional activity (entity), and even secure outside funding may not be enough to assure excellence or continuity in regional research programs. Some help has been obtained in some cases using regional development bank funding; perhaps this strategy should be examined more in the future. Regional research in Africa could be an attractive possibility if ways could be found to make it work.

NARSs, IARCs and Developed Country Research Institutions (DCRIs)

Borrowing technology and utilizing products of the global research system

Few small countries can afford to conduct research on all fronts, particularly for countries with a diverse agriculture. For these countries in particular, the role of IARCs and DCRIs as providers of biological materials and scientific resoures will continue to be required well into the future. Furthermore, in the difficult and resource-poor institutional environments that prevail in many African countries, the kinds of external assistance and partnerships provided by IARCs and DCRIs will continue to be valuable to NARSs.

The type of contribution made by IARCs and DCRIs is related to the state of development and the capacity of each NARS. Countries with weak research capacity, e.g., NARS categories I and II, benefit by directly adopting technologies produced by IARCs or DCRIs; countries with moderate capacity (e.g., category III NARS) carry out some adaptive research on IARC and DCRI products to produce their own technologies, while countries with strong research capacity (category IV and V NARS) are mostly interested in the ability of IARCs or DCRIs to deliver research products specifically addressed to their national problems.

Modes of operation in research

In the global system the idea is to solve international problems. involving all possible players in ways that use their strengths and special advantages, without loading them with tasks that are inappropriate or that distort or interfere with their own programs. Hence, elements of the global system has worked to test many kinds of relationships and methods to (i) solve important problems; (ii) transfer technology to countries and end users (farmers); (iii) strengthen the capacity of all partners to conduct research; but (iv) in particular, to strengthen the capacity of NARSs to carry out effective research.

In the early days of the IARCs, the clients of the centers were seen to be the farmers of developing countries, but few were able to conceive how the centers could reach effectively the hundreds of millions of individual farmers. Yet reaching those farmers effectively was the key to success of the IARC concept, but how could small IARCs deal with millions of farmers in disparate countries? Nearly all persons associated with the IARCs recognized that real farm problems must receive high research priority. The significant advance in thinking concerning IARC/client relationships came when it was realized that the direct clients of the IARCs were the NARSs themselves. With this perspective, that the NARSs were the direct clients of the IARCs, it was easier then to understand that the clients of the NARSs were the farmers of the respective country. Thus, along with the search for research outputs that could be translated into relevant technologies for developing country farmers, the strengthening of the NARSs to conduct relevant, effective research became a major goal of the IARCs, and the necessary steps to train, equip, and encourage effective national research were identified, explored, and supported.

Has Africa been dealt a bad hand in resources and agricultural potential?

I believe most of us would agree that Africa's agricultural performance is not what we would want it to be, and we must all question why that is so. African agriculture must improve in productivity, in profitability and in a sustainable way. How can this be achieved? As with others committed to African development, AID sometimes confronts the view that the environment for agricultural production in Africa is more difficult than that of other continents. Is this so? Are lands in Africa inherently less productive than lands in other continents? And, are those lands inherently more fragile and difficult to manage than lands elsewhere? And how about the African farmer? Is she or he less industrious or capable than farmers elsewhere? I must say I doubt it. And, I might add, the productive potential of both land and

people are important questions in regard to the sustainability of agriculture.

The question about the potential of Africa's production environment is a crucial one, for it raises the question, can African agriculture evolve and modernize, to become the vigorous, robust backbone of the economy of African states, as it should be? My thesis is that Africa is not inherently less productive in agriculture than other continents, and there is much that can be done to improve agricultural performance there.

Theoretical and achieved yields—How are we doing?

Yields of most crops in developing countries are well below their potential. For most countries, the yield gap, the yields that farmers obtain as contrasted with yields obtained on experiment stations, is also quite wide. This is also true for Africa.

In the 1970s a group of Dutch scientists undertook to determine, in their own words,"the absolute maximum food production of the world, the upper limit of what can be grown on all suitable agricultural land" (Linneman et al. 1979). To do this they had to estimate what the maximum theoretical yields for crops might be. Theoretical yields were calculated using optimum conditions of sunlight, water and nutrients, and without attack from insects and diseases. They expressed maximum potential yields in terms of grain equivalents (GE).

Table 1 shows maximum production in grain equivalents of six classes of agricultural land ranked according to potential productivity. Note that land with very high productive potential is estimated to have a theoretical yield of more than 25,000 kg GE/ha/yr (25,000 kg GE/ha would be equivalent to about 400 bushels per acre of corn or wheat).

Table 2 shows the "absolute production of grain equivalents per ha of the continents and the world" that were calculated by the team. Differences incontinents are due to differences in land quality, solar radiation, number of days that crops can be grown, and other factors relating to productivity potential. Note that Europe, Australia and North America, where scientific agriculture predominates and high yields are common, are not highest in theoretical potential. Highest potential was calculated for Latin America, followed by Africa and Asia. The high potential productivity calculated for Africa will perhaps surprise some persons, when one considers present productivity levels on this continent. The key point is that the margin between potential productivity and actual productivity may indeed be quite wide for a given continent, given existing management systems and levels of improved technology, and that significant productivity gains are possible, provided suitable technologies are available for farmers.

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Table 1. Land productivity classes for the potential agricultural land of the world (After Linneman et al. 1979).

Land Productivity Class	Land Productivity	Maximum Production, Grain Equivalent, of Potential Agricultural Land, kg/ha
I	Extremely high	more than 25,000
II	Very high	more than 20-25,000
III	High	more than 15-20,000
IV	Medium	more than 10-15,000
V	Low	more than 5-10,000
VI	Very low	less than, or equal to 5,000

Table 2. The absolute maximum production of grain equivalents (MPGE) in GE per hectare of the continents and the world (after Linneman et al. 1979).

	Average MPGE kg/ha/yr
South America	18,014
Africa	14,259
Asia	13,182
North and Central America	11,250
Europe	10,454
Australia	10,447
World average	*13,368*

Part 4. Institutional models and funding mechanisms

Institutional models for NARSs

In their study of small country NARS, Eyzaguirre and Okello (1993) listed a number of institutions that may deal with research in those countries, including agricultural research council, research foundation, French tropical research institute, ministry research organization, government agricultural research institution, multinational agribusiness, national agribusiness, parastatal, non-governmental organization, regional organization, regional research organization, regional university, and university. There are others that might be added, of course, including national research corporations (e.g., EMBRAPA in Brazil), individual IARC programs in developing countries, international or regional networks, and developed country research programs. It may be of use to discuss some of these institutional approaches in more detail.

Agricultural research council. These are "national research coordinating and planning entities based in the public sector" (Eyzaguirre and Okello, 1993). This is a model that has been used frequently in Asia (Gapasin, 1990) to help restructure agricultural research so as to focus on national needs and priorities, improve management of the NARSs, and coordinate and integrate the research activities of many diverse research organizations within a nation to meet national needs. The functions of research councils may include formulating policy, coordinating research, setting priorities, dealing with program implementation, monitoring, funding, implementing and managing research centers. Some councils play mostly a coordinating role, some a management role, some a monitoring role, some a funding role. In Asia research councils have had a positive effect by helping to consolidate very dispersed research efforts, allowing a systems approach to managing and monitoring research, and creating a favorable environment for conducting research.

Research foundations. Research foundations have been adopted recently in several Latin American countries, e.g., Jamaica, Honduras and Ecuador. Foundations have been tried partly for reasons of flexibility and ability to find resources not available to public sources, to increase the stability of funding for research, and to reduce the effect of bureaucracy on the necessary freedom and creativity of the research enterprise. Foundations can hire the outstanding scientists and create a favorable environment for research. A major problem for foundations is where funds can be obtained. To make funding secure, some type of endowment system is probably required, provided an endowment source can be identified and then convinced to make such funds available.

Ministry research organization (includes government agricultural research organizations). (Eyzaguirre and Okello (1993) differentiate between ministry and government agricultural research institutions, based on whether a research organization could be identified within a given ministry. I combine these two organizational models for the sake of this discussion.)

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Probably the most common form of agricultural research in developing countries, government agricultural research organizations can be effective or less effective, depending on national priorities relating to agricultural development, competition for funds with other public entities, how stable the funding may be for research, and the amount of bureaucracy that may be involved in the agricultural research enterprise and its management. Too often, government agricultural research lacks imagination, is imitative, is plagued with inadequate and unstable funding, may be poorly staffed and equipped, and lacks an effective incentive system for good scientists.

The challenge for AID and other donors in Africa is how to help make publicly-funded Ministry of Agriculture research (and related research efforts in irrigation, animal health, etc. in other Ministries) effective. The record to date is generally dismal.

Government research institute. Some national research institutes have been established, particularly in Latin America, to take over from former government-run institutions, often to give research more autonomy from the heavy hand of government and to create a more favorable environment for research. Some government research institutes cover most of the research program for a country, some may be more specialized.

Specialized government research institutes may be established in some cases and with good results, especially if funding is adequate and stable, high standards of research are valued and rewarded, and bureaucratic and political interference is minimized. The more specialized government research institutes usually would constitute only a part of the total NARS capability, albeit potentially important, and might suffer from isolation from the larger enterprise unless due attention is taken to prevent it. Specialized research institutes might include animal health research, pest identification and control, food processing, and research institutes related to matters such as plant or animal quarantine.

Multinational agribusiness. Some large corporations involved in international business may have research capability in a given country. Such entities are usually more interested in international screening and testing of new products or in adaptive research and applied research relating to product development than in strategic research. Included in this category could be multinational seed companies, chemical companies, machinery companies, and, today, genetic engineering companies. They do add to the overall agricultural research capability of a country, but often are necessarily mostly interested in product testing, developing and marketing. Probably few such research activities are present in most African countries, except in the larger or more developed countries such as Nigeria or South Africa.

National agribusiness. Africa does have a few national agribusiness companies, notably in seeds and other agricultural inputs, that conduct research. Such companies should be considered as clients of national agricultural research and should not be feared or shunned, as happens all to frequently. Private sector businesses and their research efforts should be seen as desirable parts of the technology transfer process and encouraged, not discouraged, to become partners in technology generation and transfer.

Parastatal. Many parastatal organizations in Africa have become heavy burdens for the countries that support them and most are probably ineffective. Parastatal research entities outside Africa, usually research units attached to commodity boards, have conducted useful research in sugarcane, coffee, oil palm, coconut and cocoa. So the model of research supported by a parastatal organization is not inherently bad, but the performance of parastatals in Africa would have to improve before the author could get excited about recommending them as a model for helping to improve agricultural research. I would be more optimistic concerning the role of parastatals in Francophone Africa that have working research relationships with French tropical research institutions.

Nongovernmental organizations. Some nongovernmental organizations have good research capability in agriculture; e.g., The Mennonite Central Committee is often staffed to do screening and testing (Level I), adaptive research (Level II) and applied (Level III) research, and where nongovernmental organizations have such capability they can make a real contribution. Some are more suited to village-level technology transfer where they could carry out Level I and sometimes Level II work. Nongovernmental organizations with capability in Levels II and III in particular could add materially to technology transfer activities in countries with only Category I or Category II NARS capability.

Regional organization. I discussed regional research institutions and some of their problems previously in Part III, but will make some summary remarks here. There are regional organizations with mandates beyond agriculture but have interest in agricultural research, e. g. Inter-American Institute for Cooperation in Agriculture (IICA), the Southern Africa Development Council (SADC) and its regional research coordinating arm, SACCAR (Eyzaguirre and Okello, 1993). Regional organizations that are effective in research coordination or implementation could play an important role in helping small countries to handle regional or continental problems that demand international solutions, but their funding and management have proved to be problematical.

Regional research organizations in Africa are not new; the colonial period saw the establishment of probably a dozen or more regional research enterprises, mostly devoted to the improvement of a single commodity, e.g., rice, cotton, oil palm, cocoa. Most of these regional enterprises did not long survive the flood of independence in the continent. Most troubling was the demise of the East African Agriculture and Forestry Research Organization which had very good staff and excellent facilities. Today, French tropical agriculture research bodies work across the Francophone countries, with good results. The problem with regional research too often has been long-term support from the benefitting countries. Without that, a regional research organization becomes an agglomeration of short-term projects supported by foreign assistance funds, and has no opportunity for life beyond the life of the projects.

Despite the problems, regional research in Africa remains attractive, if ways could be found to make it work. However, I am not optimistic such a formula will be found, unless endowments could be found to ensure institutional autonomy and scientific excellence for regional research.

Regional universities. I know of no regional university in Africa, but there are at least two elsewhere, the University of the West Indies and the University of the South Pacific, that play a role in research in their region. If effective, this could also present an attractive possibility, especially for conducting strategic research (Level IV) and applied research (Level III) .

Universities. In my opinion, universities in developing countries are a major, under-utilized resource in agricultural research. Rarely are universities even considered as a part of a NARS, nor is university research considered as an asset for national agricultural development and growth. This is a pity, for universities have a talented staff, most of whom are highly educated and trained for research. Also, post-graduate education includes a stringent research requirement that could be used as a source of strategic research (Level IV) and applied research (Level III) for the benefit of the nation. What is needed is to find ways to incorporate the talent pool within the university for the good of the country. AID recognized this in its mid-1980s effort to support agricultural research and faculties of agriculture in Africa (USAID, 1985), and attempted to link the strengthening of agricultural research capabilities with strengthened faculties of agriculture in those countries. That was a wise strategy that needs long-term commitment to succeed. Wilson (1986) recommended "the transformation of National Agriculture Research Institutes, Extension Divisions, Paraprofessional/Technical Agricultural Schools and University Faculties of Agriculture into integrated/interactive agricultural science and technology systems with social responsibility to the community for agricultural development . . . if there is the national political will to adopt such a strategy for agricultural development." This bold recommendation, coming from a professor and senior administrator in the University of the West Indies and a member of the U. N. Advisory Committee on Science and Technology for Development, should have received more attention, but alas it did not.

I have never been able to understand why the institution in a country, its university, where researchers receive their education and qualifications for research is not a key component of that country's agricultural research structure. Integrating the universities as key components of any NARS should be a policy of AID in its efforts to strengthen agricultural research in Africa. There is simply too much research talent and capability within the universities to be ignored any longer. If the problem is a fear that university researchers do not work on national priority problems, that can be solved quickly through a grant system that provides funding for research on important problems. University professors are as interested as any researcher, perhaps more, in obtaining financial support for their research.

Funding of research

Because research opportunities always exceed research funds, decisions must constantly be made about allocation of resources. Informed insight, experience and accumulated knowledge have always formed the cornerstone of decisions about research funding. Quantitative estimates of possible future benefits can serve as additional elements in making decisions. These can help in the ranking of projects, suggest where shifts in emphasis might raise total returns, and indicate research areas where expected payoff is attractively high.

In studies of funding for NARSs, it has been found that funding is most inadequate in those countries that could potentially benefit most from increased research efforts (FAO, 1985); this is particularly true for Africa. In 1982 The World Bank (1982) reported that spending on research in 51 developing countries over the previous decade had risen significantly but was still equivalent to only 0.5 percent of the value of agricultural output in 1980. For most African countries, continuing under-investment in research has been the norm. The problem is at least two-fold; obtaining enough funds to build a competent, effective NARS, and then obtaining future funds to meet recurrent costs of maintaining the capability developed.

Funding mechanisms. Recently Blase (1993) discussed various approaches for funding agricultural research in Africa. Necessarily, funding mechanisms usually follow the type of research structure and organization a country may decide to take in developing or strengthening its NARS. Public research financed by public funds is the most common method of conventional funding in most developing countriesj but such funding has many difficulties, mostly those relating to the heavy hand of bureaucracy, poor timing, and political interference. Civil wars and public unrest in many countries have aggravated the problem.

To reduce bureaucratic problems and instability of funding through traditional public mechanisms, unconventional funding mechanisms have been examined dosely in Latin America here research foundations have found favor as a way to improve stability of the NARSs. The foundation approach is not entirely new to Africa, in that the International Centre of Insect Physiology and Ecology (ICIPE) in Nairobi, Kenya, was established as the ICIPE Foundation by a group of national academies of sciences of developed countries in 1970 (Rabinowitch, 1985). Foundations, however, usually require endowments and these may be very difficult to obtain, especially for a NARS. Other nonconventional sources of funding such as earnings from royalties on commercial patents seem unattainable for most African NARSs at present.

For most of Africa, NARSs are most likely to depend on public funds. These funds should be forthcoming as part of enlightened national strategies to get agriculture moving and on a relatively safe and secure footing. Such investments in agricultural development through research have paid handsome dividends for other countries (Ruttan, 1982).

Research performance. There is no surer way to attain funding from public funds than to produce effective research results that pay dividends in farmers' fields. To do this requires good problem identification and solution. A good adage to follow for a new or recently-improving NARS is "pick the low apples first." This means choose those problems that are most obvious and can be solved rather quickly and the results, when applied by farmers, can be seen and exploited most quickly. There is no substitute for results and effectiveness in agricultural research.

Accountability of NARS. For more than two decades, many African NARSs have depended heavily on donor project funds for support. Those funds appear to be drying up. Some of the tailing off of funds is due to "donor fatigue," some is due to a concern that some African

countries have become more and more dependent on external funding for an essential activity that they should be funding themselves. Also, African NARSs must be ready to accept greater accountability to perform better in research outputs, both in quality and quantity, and to begin planning to meet future recurrent costs from their own resources. African scientists must also be more productive and relevant in their research activities. I personally would like to see a clearer sense of urgency in the research of African scientists, many of whom have proved their excellence and earned their qualifications in research institutions in industrialized countries. What is needed now is to see the effects and benefits of their research more clearly in agricultural improvement and rapid national development.

Part 5. Organizing and managing a NARS

National research planning

"Agriculture was . . . the first science—the mother of all sciences; it remains the science which makes human life possible; and it may well be that, before the century is over, the success or failure of science as a whole will be judged by the success or failure of agriculture." Andre and Jean Mayer, 1974.

Strategic planning. A strategic plan can help a NARS in its improvement and development. I like the following definition of strategy, "An organization's strategy describes the most desirable vision of the future, outlines the essential elements of a course it intends to follow to realize that vision, and provides a justification for the identified course." (Ozgediz, 1987) Components of strategy include identification of clients and beneficiaries, the external environment in which the organization will work, the internal environment, current strategy being followed, the mission of the organization, guiding values of the organization, the major "businesses" of the organization, policy choices to be made, priorities, and the operational implications of all of the above (recognizing that a strategy represents a scenario for organizational change).

Strategic planning for NARSs in Africa would include the desired scale and scope of the NARS in question, the category of NARS development desired or likely to be attained, possible partners in the research enterprise, modes of operation in research, and so on.

Priority setting. Early decisions should be made about the research priorities to be tackled by the NARS and, then, the amount of resources to be allocated to them. Small NARSs must avoid too broad a scope, i.e., taking on too many topics and in too general a way. An eminent agriculturist, the late Dr. Richard Bradfield, used to say, "There are many problems in agriculture; some of them are important." The subject of priority setting is subjective and has many facets to it, but the two questions posed by Ruttan (1986) perhaps best lays out the nature of the task: (1) "What are the possibilifies of advancing knowledge or technology is resources are allocated to a particular commodity, problem or discipline?" and (2) "What will be the value to society of the new knowledge or the new technology if the research effort is successful?"

Ruttan goes on from the first two questions to calculations concerning the following:

- "A comparison of the ratio of research expenditure by commodity to the value added in farm production for each commodity."
- "A comparison of the ratio of research expenditure by factor (or resource) input to the cost of the factor (or resource) in production."

- "A comparison of the ratio of research expenditure to the value added at each stage in the food production chain from purchased inputs to the consumer."

- "A comparison of the ratio of research expenditure in each field of science to the value added for each commodity, factor, and stage."

Table 3 presents some strategic questions that a country in particular must ask in planning for the improvement of its NARS (Eyzaguirre and Okello, 1993). These questions comprise a checklist any country might follow in strategic planning.

Scientific human resource needs

The most important resource of a NARS is a qualified staff of scientists and technicians. Without them, the research enterprise will never be successful. How many and of what type a research staff should comprise are questions that should be answered during the strategic planning process to define national priorities and decide the scale and scope of the NARS. Suffice it to say, a country should strive to identify superior students with a thirst for knowledge and a proclivity for research, and then find ways to help them become educated and schooled in conducting research. The IARCs, DCRIs, development banks and bilateral aid agencies can and should be able to assist in this effort.

Training. Part of the strategic planning for a NARS is the whole subject of education and training of scientists and technicians.

The IARCs are a good source of help in training young and mid-career scientists in research and its conduct. IARCs have a special budget set aside for training, and most will reserve the bulk of those budgets for candidates from developing countries. The IARCs are a good place to send mid-career scientists for refresher work or for training in advanced research techniques.

IARCs have largely discontinued their training efforts in production techniques, but usually will make staff resources available to help countries to conduct in-country training. This sometimes may be done for topics concerning research methodologies or other techniques that are required by more than a very few scientists at most.

In the absence of a good university in the country or region where young scientists can obtain advanced education in a desired research discipline, developed country universities can be good places to obtain such education. For some of the more specialized areas of study, universities in industrialized countries may be the only real option for bright students.

Career development. If a NARS wants to retain and keep its best scientists, it must make provision to help ensure the scientist has a fruitful, fulfilling and productive career. An incentive structure that allows expression of individual creativity and innovation, recognizes achievement, and rewards accomplishment can go a long way toward meeting this need. Also, the NARS should it clear to the scientist that the organization is interested in the scientist and his/her career development. A real asset today in career development is the possibility that good NARS scientists can participate in international teams conducting research on matters of global importance. Many scientists find sufficient satisfaction in such participation that they will remain in their country, working on high priority problems, but using their global involvement as a kind of professional and intellectual lifeline to the wider scientific community.

Criteria for assessing a successful NARS

In 1994 an assessment was made of the Egyptian National Agricultural Research Project

(NARP) by an interdisciplinary panel (York et al., 1994). Egypt has a NARS that would fit in Category V of NARS development, that of a fully-fledged capability enjoying peer relationships in some fields with IARCs and DCRIs. The assessment panel report listed criteria that were used to assess the performance of the NARP over the past several years. These criteria were: increased agricultural output; *the ability* to deal with change; to introduce new enterprises, to introduce new technologies and to present new opportunities; to deal with emergencies; to identify important problems and constraints; and to solve important problems; an able, well-educated pool of scientists; an institutional management capability to make the best use of available resources and to provide an environment in which scientists can make best use of their talents; facilities, equipment and support sufficient that reliable research can be done and problems solved; an institutional culture that places heavy emphasis on serving the farm and farmer; a system that gains the confidence of the agricultural community; and international recognition and effective collaboration.

National scientific services and regulatory matters relating to a NARS

All countries have technical needs that may not relate to research directly, but that are dependent upon a research capability to make them successful. The following list of scientific and technical services arising from research and development are taken from the so-called Frascati Manual, a document of the OECD (1970). Not all of these will relate to each country but at least a part of the list may be relevant.

- scientific library and information services
- scientific testing and standards services
- museums, zoological, and botanical gardens
- technical and scientific advisory, consultancy and extension services, including patent offices, and related activities
- feasibility studies (for example, engineering projects)
- general purpose data collection (e.g., on natural environment and land use which includes routine mapping and geological, geophysical, hydrological, meteorological, oceanographic and natural resource surveys.

Research cooperation

NARSs in Africa should plan to plug into the services and advantages presented by the global agricultural research system. The global system provides a kind of additive or multiplicative effect on national research—it serves as a source of new genetic materials, new methodologies, training in advance research techniques, and it provides a bridge to technical advances elsewhere. Each NARS should set aside resources to make certain their scientists are active in the international problem-solving research process that is pertinent to their interests and that of the country. Countries that make effective the connection with the global systeml will find that they have dozens or more world-class scientists, working on their problems or problems closely related to those that face them, and all without cost to the NARS itself. This is exciting.

Networking. Research networks have proliferated as a way to assemble team of scientists to solve pressing continental or global problems. NARSs with capability to do research in Categories IV and V in particular can become effective partners in collaborative research networks. In some cases Category III NARS can be effective partners. Category I and II NARS can receive new ideas from networks and can obtain some necessary specialized training for staff, as well as useful materials and information, but will not have the capability in most cases to conduct research within a network. An exception might be in international nursery networks for'testing of superior varieties or germplasm. Here screening and testing (Level I) and adaptive research (Level II) capabilities of the smaller NARS may be helpful in allowing their effective participation.

Networks are not a panacea; often a network is more "net" than "work." For a fuller discussion of networking as a way to achieve research results, and some of its limitations, see Plucknett et al. (1990).

Developed country sabbaticals, secondments. A NARS that establishes some research capacity should keep in mind the fact that many scientists from developed countries would like to work for a time in a particular place or on a particular problem that is only available within a given African country. Such sabbatical leaves or secondments should be encouraged. They can be a source of new ideas, for stimulation of partnerships in research between the visiting scientists and his/her institution, and some of the best and brightest of the particular NARS scientists, or for post-graduate education of promising young NARS staff. Here is where new ideas emerge and exciting new research starts, and life-long friendships and professional associations begin. All NARSs should keep close watch on such opportunities. Housing and local support for the visiting scientist may be a problem, but such concerns might well be met through creative design of the collaborative effort, including financial help from the visiting scientist's home-country.

Network of research stations

"While findings from neighboring countries may be 'borrowed,' there is no substitute for internal research: conditions, problems, and resources vary too much from one country to another. For the same reason, it is not possible to limit research to a single location in the country, since conditions can also vary enormously from place to place." (G. J. Gill, Agricultural Research in Bangladesh, 1983).

Each country should develop a network of research stations to provide research sites representative of a large share of the agricultural production conditions of the country. Care must be taken, however, not to develop more stations than can be used effectively and supported, and that locations of such stations are chosen for scientific and agroclimatic reasons, rather than political. Stations can be of several types: single-commodity stations (e.g., cotton, coffee); multi-commodity stations, pure disciplinary stations working mostly on problems relating to a particular discipline; entomology, pathology, animal health; or systems-based stations. Research at such stations may be done by resident scientists who carry out most of the

research; visiting staff from larger research centers who carry out part of their research at the station; or the research may be carried out by a combination of resident and nonresident staff. Each of these methods of carrying out research has its own strengths and weaknesses.

Research stations need field and laboratory facilities suitable for good research. Facilities do not need to be elaborate, but they should be clean and orderly, and equipped with reliable equipment to ensure accurate measurements for quality research. Research records should be kept daily and accurately, and filed in a safe place. Daily records relating to temperatures, rainfall, humidity, windspeed and direction, etc. should be routinely recorded.

Too many research stations in Africa are run-down, with broken or unservicable equipment. Stable budgets can help ensure good station management, but so can daily attention to keeping "socks up" and a clean and orderly environment. Research requires daily attention to small things; most good researchers distrust results from run-down, weed-infested stations where little care or attention seems to be given to detail. Research stations must deal with large ideas and important problems, but they do not have to look like the farm of "Peter Tumbledown" in the process of that work.

Information exchange

Information exchange relating to a NARS rarely receives the attention it deserves. Agricultural research is after all a search for knowledge and devising ways to ensure its application in daily life. All agricultural scientists should be 'information-conscious,' meaning they should constantly search for ways to communicate their ideas and thoughts more widely to others for peer assessments, tests of validity and finding ways to ensure their application.

There are at least two parts to information exchange: (1) communication with scientists and agricultural research organizations and (2) communication with external audiences, induding the public and the final clients, farmers. Scientists need to know what is going on in larger fields of science, including basic science. Also, they need to know what is happening at other research institutions, particularly those within their own country and in places with agro-climatic and production conditions similar to their own. Scientists need to travel professionally, to other research institutions and to professional meetings. Cut them off from such professional travel and exchange and they will quickly dry up intellectually and professionally.

Information resources that are too often inadequate or lacking:

- *library.* A good library is an essential part of the research infrastructure. Too many libraries in Africa are limited, and even where they are not, they are often located in central urban areas, and a long way from field stations where the scientists work. Travel to libraries for library research by field scientists is a good investment by NARS. If I had my way, every scientists would have to work in the library for a full day or more at least once a month, just to keep up with the related fields and to consider new ideas.

- *research journals.* Scientists need to be able to keep up with research in their fields; In most cases specialized research journals are the best way to do this. Most African NARS possess woefully-inadequate journal holdings and most are far behind the current journal issues. If allowed to continue, this inadquacy will ensure a weak NARS with little creativity or innovation.

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Part 6. Some personal thoughts

I have been privileged to see tremendous improvements in agriculture during my lifetime, developments that caused this century to experience the greatest transformation of agriculture in human history. That transformation is still continuing and will continue into the next century if we make the right choices. Africa could and should enjoy agricultural transformation, provided African countries, and their friends and supporters, also make the right choices.

Some lessons learned during the 20th century the century of dramatic agricultural improvement and growth.

- Technological change in agriculture depends greatly on a constant flow of new technologies to the farmer, allowing the producer a wide range of options.

- Science-based agriculture can bring about rapid change on the farm and can speed the transformation of rural areas from subsistence agriculture to a much more productive commercial agriculture, and eventually in many cases, to broadly-based mixed agricultural and industrial economies.

- As science-based agriculture moves ahead, a private sector involved in food processing, mercantile operations including supply of inputs and other materials, transportation, and other services can emerge.

- As agriculture improves and farmers succeed, many of them begin to specialize in certain crops or products. In many cases such specialization results in the growth of private enterprises established and led by farmers or former farmers. Thus farmers often lead the way in building the private sector in rural areas.

- Each country, no matter how small, should have enough technical capacity in agriculture to identify their own agricultural and natural resource management problems, to set priorities, and find ways to solve those problems, whether alone with local resources, through partnerships with other nations and institutions in the global agricultural research system, or by bringing in technical people from abroad.

I like homespun philosophers, and probably my favorite is Yogi Berra, the baseball manager. One day when Yogi was managing the New York Mets his team had lost another game, badly, but this time even more badly than usual. A sportswriter asked Yogi what happened. "Oh", said Yogi, "we made the wrong mistakes." Now that statement is indeed humorous, but it is also profound. There are mistakes made that are not "wrong", in the sense they of being so serious, but then there are those mistakes that what my Dad would have called "real humdingers", the ones you really want to avoid and would like to have back. I believe AID and other development assistance organizations and its developing country partners and

should avoid making the "wrong mistakes" concerning agriculture and agricultural research, both in Africa and elsewhere.

Perhaps, though,I shouldn't speak so much of agricultural research here as of the need for an improved and expanded knowledge base to make agriculture better and to manage better the production environment, and more importantly the natural resource base. As I see it, almost every problem we will face in the 21st Century will require improved knowledge on natural processes in the realms of biology and the physical environment, and the interaction of those processes with human activities, notably the production of the goods—food, fiber, fuel—humankind needs to survive. New knowledge can come from two general sources and in two different ways; (i) trial and error, and (ii) organized efforts to try to understand what is going on and what might happen, and trying to find ways to develop technologies to overcome the major difficulties. Africa has been operating on trial and error for millenia and it has proved to be a slow, uncertain and generally unsatisfactory way of doing things to meet modern challenges. The second approach, which can result in necessary developments based on scientific agriculture, requires scientific discovery and technology innovation. I believe we should choose the latter approach.

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Bibliography

Blase, Melvin G. 1993. *An analysis of funding alternatives for agricultural research with special reference to Africa.* Dept. of Agricultural Economics, University of Missouri, Columbia, MO. AEWP 1993, 28 pp.

Bonte-Friedheim, Christian. 1991. *NARS in a new age.* Adapted from a presentation to the International Centers Week, CGIAR, Washington, D.C. Oct. 28–Nov.1, 1991. 6 pp.

CIRAD. 1989. *Agricultural research for rural development in Africa. An evaluation of the Sudano Sahelian Zone. Part III. Summary and Suggestions.* CIRAD, DSA—1989. 4,44 pp.

Eyzaguirre, Pablo. 1991. The Scale and Scope of National Agricultural Research in Small Developing Countries: Concepts and Methodology. ISNAR Small countries study paper No. 1. ISNAR, The Hague, Netherlands. 54 pp.

Eyzaguirre, Pablo B. and Andrew E. Okello. 1993. Agricultural research systems in small countries implications for public policy and administration. Public Administration and Development 13:233–47.

Eicher, Carl K. 1992. Rezntalizing the CGIAR System and NARSs in the Third World. Staff Paper, Dept. of Agric. Econ., Michigan State Univ., East Lansing, Michigan. 27 pp.

Food and Agriculture Organization of the United Nations. 1972. Accelerating agricultural research in the developing countries. Reprinted from The State of Food and Agriculture 1972. pp. 141–64. FAO, Rome.

Food and Agriculture Organization of the United Nations. 1978. FAO and Agncultural Research: FAO's service to national agricultural research in developing countnes. FAO, Rome. 28 pp.

Food and Agriculture Organization of the United Nations. 1984. Land, Food and People. FAO Economic and Social Development Series, FAO, Rome. 96 pp.

Food and Agnculture Organization of the United Nations. 1985. National agricultural research systems: The management factor. Ceres 18(3), no. 105 (May–June, 1985), p. 1-17.

Food and Agriculture Organization of the United Nations. 1987. *Role of Regional Research Programs in Africa and important principles in their effective operation.* FAO, Rome. W/P7987, 12 pp. and 6 p. annex.

Gamble, W. K. 1984. *Improving the global system of support for National Agricultural Research in Developing Countries.* ISNAR Reprint Series No. 1, 11 pp.

Gapasin, Dely P. 1991. *The Agricultural Research Councils of Asia.* ISNAR, The Hague, Netherlands. 28 pp.

Gill, G. J. 1983. *Agricultural research in Bangladesh: Costs and returns.* Bangladesh Agricultural Research Council, Dhaka-15, Bangladesh. 15 pp.

Jahnke, Hans E., Dieter Kirschke, and Johannes Lagemann. 1987. The Impact of Agricultural Research in Tropical Afnca. A study of the Collaboration between the International and Nahonal Research Systems. CGIAR Study Paper No. 21, Consultative Group on International Agricultural Research, The World Bank, Washington, DC. 175 pp.

Jain, H. K. 1989. Organization and Structure in National Agricultural Research Systems. ISNAR Working Paper No. 21, International Service for National Agricultural Research, The Hague, Netherlands. 49 pp.

Linneman, H., J. DeHoogh, M. A. Keyser, and H. D. J. Van Heemst. 1979. MOIRA: Model of International relations in agriculture. Report of the Project Group, Food for a Doubling World Population. Amsterdam: North Holland.

Lopez, Juarez Brandao. 1985. Managing research through a public corporation: An assessment of the Brazilian experience. Ceres 18(3), no. 105 (May–June, 1985), p. 17–21.

Madamba, Joseph C 1985. An Asian approach to research management training. Ceres 18(3), no. 105 (May–June, 1985), p. 22–27.

Mayer, Andre and Mayer, Jean. 1974. *Agriculture: The Island's Empire.* In: Science and Its Public: The Changing Relationship. Daedalus. Summer, 1974, pp. 83–95.

Moseman, A. H. 1970. Building Agricultural Research Systems in the Developing Nations. New York, Agricultural Development Council.

Mosher, Arthur T. 1966. Geffing Agriculture Moving. Essentials for Development and Modernizahon. Praeger, New York, Washington and London. 191 pp.

OECD. 1970. Document DAS/SPR/70.40. The so-called Frascati Manual. Paris. Organization for Economic Cooperation and Development.

Oram, Peter A. 1980. *Collaboration between national and international institutions in the development of improved agricultural technology for low-income countries.* Paper presented at a symposium on "The Interplay of Science, Technology, and Values in Agricultural Transfers," annual meeting of the American Association for the Advancement of Science, San Francisco, January 1980. 71 pp.

Oram, Peter A. 1981. Recurrent cost problems of agricultural research and extension in developing countries. Paper presented at OECD/DAC "Workshop on Linkages Between Agricultural Research and Farmers in Developing Countries." 1-14 May, 1981, Paris, France. (Peter Oram is with the International Food Policy Research Institute, IFPRI, Washington, D.C.). 41 pp.

Oram, Peter A. and V. Bindlish. 1981. Resource Allocations to National Agricultural Research: Trends in the 1970s. ISNAR, The Hague, Netherlands; and IFPRI, Washington, DC. 104 pp.

Ozgediz, Selcuk. 1987. *Strategic planning—Concepts and issues.* CGIAR Secretariat, The World Bank, Washington, D.C. 15 pp.

Pardey, Philip G. and Johannes Roseboon 1989. ISNAR Agricultural Research Indicator Series: A Global Data Base on National Agricultural Research Systems. Published for ISNAR by Cambridge University Press, Cambridge, New York, Port Chester, Melbourne, Sydney. 547 pp.

Peterson, Willis L. 1976. Returns to investment in agricultural research: Results and implications. Photocopy of paper by Dr. Peterson, who was Professor of Agricultural and Applied Economics, University of Minnesota, St. Paul, Minnesota. 6 pp.

Plucknett, Donald L. 1989. "The global agricultural research system Geared to the needs of an expanding population?" Paper presented at the World Food Production Conference, Rio de Janeiro, Brazil, Nov. 6–9,1989. (Conference sponsored by IMC, Inc.). 16 pp.

Plucknett, Donald L. 1991. *Saving lives through agricultural research.* Issues in Agnculture, No. 1, Consultative Group on International Agricultural Research (CGIAR), CGIAR Secretariat, The World Bank, Washington, D.C. 20433, 20 pp.

Plucknett, Donald L. 1993. *Science and agricultural transformation.* International Food Policy Research Institute (IFPRI) Lecture Series No. 1, IFPRI, Washington, D.C. 34 pp.

Plucknett, Donald L. 1994. The global agricultural research system: The U. S. stake. Paper presented June 13, 1994, 30th Annual Meeting, Association for International Agriculture and Rural Development (AIARD), Washington, D. C.

Plucknett, Donald L. and Nigel J. H. Smith. 1986. Sustaining agricultural yields: As productivity nses, maintenance research is needed to uphold the gains. BioScience 36(1)40–45.

Rabinowiotch, Victor. 1985. *Lessons from history.* ICIPE Science Press, The International Centre of Insect Physiology and Ecology, Nairobi, Kenya. April 14, 1985. 17 pp.

Ruttan, Vemon. 1982. Agricultural Research Policy. University of Minnesota Press, Minneapolis. 369 pp.

Ruttan, Vernon W. 1991. *Challenges to agricultural research in the 21st Century'* In: Pardey, P., J. Roseboom, and J. R Anderson, eds. Agricultural Research Policy: International Quantitative Perspectives. Cambridge: Cambridge University Press. pp. 399–411.

Tamboli, P. 1991. *The World Bank experience in supporting research for development and challenges faced by Indonesia's Agricultural Research and Development Agency.* Paper prepared by Mr. Tamboli (retired) for a meeting on agricultural research in Asia, 1991. 28 pp.

Wilson, Lawrence A. 1986. Mobilization of university resources in science and technology for agricultural development in developing countries. Prepared for United Nations Advisory Committee on Science and Technology for Development, January, 1986. The University of the West Indies, St. Augustine, Trinidad, W. I. 15 pp.

World Bank, The. 1978. The present state of agricultural research in developing countries. A background paper for the World Bank Policy Paper on Agricultural Research [paper prepared by W. J. MacNally, Consultant, for the Agriculture and Rural Development Department, World Bank, Washington, DC. 90 pp. and 2 annexes.

United States Agency for International Development. 1985. *Plan for supporting agricultural research and Faculties of Agriculture in Africa.* Agency for International Development, Washington, D.C. 25 pp. and annexes.

Winrock International Institute for Agricultural Development. 1989. Agricultural Potential of Mid-Africa: A Technological Assessment. Winrock International, Petit Jean Mountain, Morrilton, Arkansas.

York, E. T., Jr., Donald Plucknett, Jim Ross, Harold Youngberg, and Leticia Solaun. 1994. The National Agricultural Research Project's Contributions to Significant Advances in Egyptian Agriculture. Report of a 1994 USAID-sponsored mission to evaluate the National Agricultural Research Project in Egypt. Submitted to USAID/Cairo by Tropical Research and Development, Inc., Gainesville, Florida. 136 pp. and annexes (97 pp.).

Rice production position paper

by

R.L. Tinsley

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Executive summary

From a production and consumption perspective, rice in sub-Saharan Africa is only a minor crop, claiming only 5,000,000 ha in the continent. However, rice is a major imported cereal: Some 3,000,000 tons are imported annually, representing almost 20 percent of the world's total rice imports. Because of the its importance as a imported grain, many African governments are interested in increasing local production to self-sufficiency levels.

Rice is produced under a highly diverse set of environmental and socioeconomic conditions. These include irrigated rice, rainfed rice, upland rice, and swamp or deepwater rice. The vast majority of African rice cultivation is either upland rice under shifting cultivation or rainfed rice in paddies nestled in the inland valleys. Only a limited amount is irrigated. Because most of the rice is produced in relatively small tracts surrounded by upland crops, most farmers manage both paddy and upland lands. The interaction with the upland crops introduces an element of complexity to understanding the rice production systems and their improvement. Under such circumstances, farmers tend to give initial priority to the upland crops because the extra water available in the paddies from irrigation, runoff, or seepage increases the opportunity time for managing these lands in comparison to the adjacent, nonwater-enriched upland areas.

Political pressure to reach self-sufficiency may be resulting in support for rice research and production out of proportion to current rice production or the potential to increase rice production within the total agriculture sector. There is a need for governments to consider the most appropriate ratio of area cultivated in rice to the number of agriculturalists working in rice research and extension. Likewise there is a need to keep the support for irrigated rice in its proper perspective relative to the rainfed areas. This may require enhancing the perception of rainfed rice potential. While there is some opportunity for expanding paddy lands, any expansion of both irrigated and rainfed rice needs to make certain that water is available and is not already committed. There is probably more opportunity for increasing yields rather than area, particularly in rainfed areas. All rice production improvements will depend on government policies and infrastructure investments that encourage farmers to produce rice in preference to the farmers' alternative crops.

Support for rice development is available from the international centers such as IRRI, WARDA, and IITA. Of these, WARDA has the largest mandate but is restricted to West Africa. IRRI can provide support, particularly in germ plasm exchange but not for in-depth evaluation of the system complexities. IITA has done the most in-depth research in the past, particularly with the inland valleys, but more recently it has been encouraged by its donors to concentrate on other activities. Bilateral assistance is available from China for developing small irrigation schemes, from the French through IRAT, and from JICA with an annual six-month training program conducted in Egypt.

As with all current development efforts in Africa, some consideration has to be given to the

impact of the AIDS epidemic. In the case of rice, if the impact of AIDS is land consolidation and the mechanization needed to operate larger holding, then the impact on rice production would be a decline in area cultivated because the small size of the paddies would hinder mechanization.

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Diversity of rice in Africa

Developing a position paper for all of sub-Saharan Africa on sustainable technology for rice production requires a few initial comments about the diversity of rice production in Africa and the consequent difficulty in generalizing over such a large area. First, it must be recognized that sub-Saharan Africa, while primarily a tropical area, covers highly diverse physical environments including both flooded paddy and uplands with varying potential to support rice cultivation. These physical environments serve as an on-off switch that determines if rice can be produced or not. The physical environment tends to be fairly easy to identify and map.

Once the physical environment is favorable, the socioeconomic conditions become primary in promoting or restricting rice production. The socioeconomic conditions tend to reflect national policy decisions and result in such variations as Senegal's desire to import only broken rice (the only country in the world specifying broken rice for general consumption) and Cameroon finding it cheaper to import U.S. rice to the capital Douala than to mill and transport rice from its own production centers to Duala, even though the actual production costs are similar (the major constraints in Cameroon are the high cost of transportation due to government levys on diesel fuel combined with the desire to support the excessive capacity of the public-sector rice mills with minimum subsidies).

While the reasons for these circumstances are not clearly stated in the source materials, it is easy to appreciate how civil servants of newly independent countries having limited experience or the previous colonial administrators looking for ways within their financial resources and administrative capabilities to make their respective economies function, might

a. Look at the cheap price of broken rice on the world market as an the most economical means of providing essential grain supplies. If broken rice is the only grain on the market, people adjust to it, learn how to make porridge or other dishes with it, and develop a taste preference for it.

b. View taxing imported fuel is an administratively easy and assured means of collecting needed revenue. The need for tax revenue becomes more important than the detrimental, if somewhat hidden, impacts of high fuel costs on the local economy for both producing goods and transporting them to market. Another contributor is the state's desire to recover the operating cost of state-owned mills, whose capacity was based on overly optimistic production projections that its own policies prevent from fully materializing—in what becomes a rather vicious circle.

With these brief remarks on the diversity of rice in Africa, any generalized statements presented must be validated according to specific local or national conditions under consideration.

Rice in African economies

Rice in most African countries is a relatively minor crop, contributing only 15 kg/person/year to the diet. The staple crops on the continent are maize, sorghum, and millet. In comparison to the nearly 100 kg/person/year of rice consumed in Asia, rice consumption in Africa represents approximately one-sixth of the annual caloric intake.[14] In rice-producing regions, rice may increase to become the primary staple. However, while rice production is limited, rice is a major imported grain with annual imports of 3,000,000 tons (table 1), or nearly 20 percent of all rice imports worldwide, an amount that would require at least 1,000,000 additional hectaresof rice cultivation to equal. The import demand reflects that rice is the easiest, least energy consuming grain to convert from harvested grain to a table consumable staple and its overall availability on the world market in a ready to consume form. As a major imported foodstuff, it could become the staple cereal for urban areas and masses of people moving from country to city. The consumption of rice in the urban areas may therefore be considerably higher than the national average. For this reason, national planners trying to reduce imports could place a higher priority on rice production and supporting rice production than it may deserve from a production potential based on current and projected area cultivated and potential yield increases relative to the potential production improvement of the more traditional staple crops of Africa.

Consistent with the limited amount of consumption, rice is not a major crop in most parts of Africa. Africa has only 5,000,000 ha cultivated in rice and accounts for only 3 percent of the worlds's rice production. Only Madagascar cultivates over a million hectares and has rice as its primary staple. This is followed by Egypt (which is not considered part of sub-Saharan Africa and thus is not part of this analysis), with 500,000 ha. Other countries with more than 100,000 ha include Nigeria, Guinea, Ivory Coast, Liberia, Mali, Sierra Leone, Tanzania, and Zaire (table 2). These averages represent less than 10 percent of the cultivated lands of the respective countries. The remainder of countries in Africa produce considerably less. The yields are also low. In 1980 the average national yields were in the 1 to 1.5 t/ha range. This is a yield level that would barely return the calories needed to produce it. At these yield levels, rice would remain primarily a farm-level subsistence crop. In contrast, in Asia yields of 5 t/ha are realistic targets even for rainfed areas.

Rice production systems in Africa

Rice in Africa is produced under irrigated, rainfed, and upland conditions. Rainfed rice may be divided between normal rainfed rice and what is referred to as swamp rice, which is grown in areas with a deepwater potential. Given the rather limited total area of rice, it has to be assumed that much of the rice, both irrigated and rainfed, is produced in rather limited paddy

[14]Author query: Is this correct? 15 approx. = 1/6 100. But here and again later you assert that rice accouts for 1/6 of the Africans' annual caloric intake. With so little rice produced in Africa, that seems to be a huge fraction.

tracts, with upland crops in the adjacent areas and villages between the two production systems. The combination of farmers managing both paddy and upland crops introduces a level of complexity to the system, particularly if you are an agricultural worker committed solely to promoting rice.

In such combined systems, the extra water in the rice land (either the water naturally collected from runoff or seepage or from irrigation) provides an element of flexibility to the paddy lands relative to the uplands. Thus when the rainy season begins, farmers first concentrate their cropping activities on their upland holdings. Only when the upland crops are under control will farmers turn their attention to establishing the rice paddies. The extent of delay in working the rice paddies will depend largely on the percent of the farmer's holding devoted to each. Thus a farmer with mostly rice paddy fields will initiate work fairly early while a farmer with mostly upland fields will not initiate work in his paddies until later in the season. A typical delay would be four to six weeks.

Irrigated rice. Irrigated rice in Africa is grown on 465,000 hectares, or only 11.3 percent of the rice lands. If Malawi is typical, most irrigation systems are relatively small, run-of-the-river diversions without storage facilities. Such systems can provide the water necessary for at least one crop per year, if not two, depending on the individual hydrography of the diverted stream and seasonal rainfall in the catchment. With a reliable water supply, the irrigated rice will be the most productive of the rice systems. Target yields for irrigated rice should be 5 t/ha or more. The irrigation provides considerable stability to the command area both in terms of adequate water for the entire scheme and reduced flood hazards for the lower portions of the tract.

However, upland crop lands will still receive priority when the rains come, and thus most paddy operations will be delayed. In Malawi it was typical for farmers to delay operations in the irrigation schemes for six weeks after the onset of the rains. Also, the irrigated lands were used more extensively during the dry season, when there was no competition from the uplands, than during the wet season. If 1 km is a reasonable outer limit for commuting from home to field, an irrigation scheme would have to be approximately 2 km wide before villages would be located inside the scheme and farmers would concentrate on cropping only rice. Irrigation systems of this width would require a fairly good base flow or a reasonable storage structure, and therfore they are rare in Africa. When you factor in a reasonable length, the total area of one such large scheme would represent almost all the current irrigated rice acreage in Africa.

Other than the initial timingof planting, the actual agronomic management practices for irrigated rice production are fairly straightforward according to the local production recommendations for either transplanted or directed rice. There will be little problem with accessing all paddies for to apply fertilizer or paddies with drying out and promoting weed growth. The biggest concern may be operating the irrigation systems, especially synchronizing them with the farmer's actual practices (after taking into consideration the priority given to upland cultivation). The tendency is to try to operate such systems to maximize production in the

tract, disregarding the upland areas. Also, in run-of-the-river systems, the availability of water will decline during the dry season. Early maturing lines would help assure that late-planted crops will be harvested with minimum late-season drought stress and would enhance the second crop potential—even with the farmers' early efforts committed to upland crop production.

Rainfed lowland rice. Rainfed lowland rice is produced on 1,258,000 ha or 30.6 percent of the rice lands in Africa. Much of this is in what is referred to as inland valleys, which represent a total of 10 to 20 million ha and include some of the most intensively cultivated lands in Africa. The extra water available in the bottom of the valleys allows double cropping with rice during the rainy season followed by upland crops, mostly high-value vegetables, during the dry season.

The rainfed environment adds two additional elements of complexity to the system. The first is the dependency on rainfall. This introduces four different variables with little relation between them and thus little predictability. First, the rains are not uniform but come in a series of surges and lulls depending of the movement of the inter-tropical converge zone, the African equivalent of the Asian monsoon circulation. Surges will last one or two weeks, with lulls of two to three weeks. Second, the onset and decline of rains have a three week year-to-year variation from the norm for a total spread of six weeks. Third, the total rainfall during the season has a 30 percent annual variation from the norm, and fourth the monthly rainfall will have over 50 percent variation from the norm. The above values are based on the Asian monsoons, for which the Himalayas provide a stabilizing effect on the general circulation.

In Africa the variability is somewhat greater and less predictable. This might easily restrict the spread of rainfed rice over entire plains as found in Asia, even if the normal rainfall and similar soil types would predict its possibility. This rainfall variation severely compromises the farmers' ability to anticipate and accurately plan his rice production activities. The level of variation is really too high to base planning on "normal" rainfall patterns. Cultivation requires more reacting to the incident rainfall as it occurs.

The other source of additional complexity is the landscape. Even more than irrigated systems, rainfed rice will be sensitive to microchanges in topography as well as having upland cropping areas along the sides. Rainfed rice tracts typically contain from 100 to 2,000 ha of paddy lands. To maximize the amount of impounded water these tracts will normally be placed across the natural drainageways, where there is some natural water enrichment from runoff and seepage from adjacent higher lands, and further up the catchment basin. Thus, not only do farmers have to contend with the upland-lowland mixture, they also have to contend with considerable variation within the tract. Along the upper edges of the tract, keeping paddies flooded will be the problem and the rice will suffer from drought stress and weed infestation during lulls in the rains. Meanwhile, in the middle of the tract, perhaps less then 100 meters away there will be deepwater conditions. The water level will frequently be over the bunds, and the rice will effectively be growing in a slow-moving stream with a water depth of 50 to 80 cm during surges in the rains. Rice in these areas will need some elonga-

tion potential to keep the plants above the water level. A typical example would be the paddy fields just north of Karonga in Northern Malawi.

In a typical rainfed rice tract, the crop establishment has to be integrated with the surge and lulls of the incident rainfall. Once the farmer completes his upland crop establishment and focuses his attention on the rice lands, he may have to delay his activities slightly until the next surge of rains. Then with each surge of rains the farmer will get some paddies prepared and planted. Most likely he will start with the lowest land he manages, closest to the middle of the tract, and work toward the sides. This is only natural because the middle of the tract will have the most water early in the season, give the most assured yields, and will need to be established prior to deep water limiting access. Early establishment will also allow early harvest, which maximizes the opportunity for upland cropping during the dry season on residual moisture and seepage. Once the farmers begin working in the paddies, they will work toward the sides of the tract until they either run out of paddies or time, whichever happens first depending on the total rains of that particular season. Thus the side paddies will be established last, if at all, and will therefore be most drought stressed. The effect of this integration with incident rains is a loss of effective, accurate planning, particularly concerning seedling age for transplanting. This in turns restricts the use of early maturing lines for transplanting because they will tend to start tillering if transplanting is delayed waiting for the next surge of rains. Transplanting after tillering has begun will result in considerable yield loss.

This much variability over such a short space and the limited amount of total area in rice means that varietal development needs to focus on versatility over the range of conditions rather than trying to develop several different lines for different portions of the tract. Thus the need may be for lines that have a combination of elongation potential to accommodate the deep water conditions in the middle and drought stress tolerance for the side areas. Such demands are not necessarily mutually exclusive, but they require a comprehensive selection process that covers the median and both extreme conditions.

The actual agronomy practices will also have to be flexible enough to accommodate the diverse conditions across the paddy tract. In the center of the tract, with the water over the bunds, access can become a major problem. This will restrict the ability to apply a fertilizer top dressing but reduce the problems of weed control. Even if you could wade to the paddy, broadcasting the fertilizer would be questionable, as a substantial portion could easily drift downstream to the neighbors' fields or out of the rice tract altogether. Furthermore, if the plants had to elongate with the water depth, excessive nitrogen could cause severe lodging. Basal applications may be the only fertilizer that can be effectively applied and utilized in the lower paddies. While these paddies may have the best water control and most assured yields, they will most likely not be the highest yielding.

On the upper edges of the tract, the major problem could be weeds. With these paddies frequently unflooded, weeds will flourish and become competitive with the rice. Thus prior to getting the rice fully established it may require two or three sessions of hand-weeding, at approximately 300 hours per hectare. With the alternate flooding and drying cycles fertilizer

applications need to be split into multiple doses of small amounts to avoid denitrification losses. The middle paddies with reasonably assured ponding of water but not flooding will be the most fertilizer responsive and highest yielding.

This level of landscape complexity makes agronomic recommendations difficult both to develop and to comply with. It requires a flexible approach to production practices that ultimately recognize the farmers' right to adjust practices to specific conditions of each paddy. But the farmers ultimate objective is not to maximize the yield of each paddy but to maximize returns from the collection of farm enterprises, a practice that requires the continuous evaluation of quality vs. extent in which farmers will normally opt for managing a larger area at less than recommended management level rather than a smaller area with full recommendations. Also, fields such as the weedy, late-planted paddies along the upper edge may get abandoned in favor of more productive paddies in the middle or bottom of the tract. The whole of this pattern is in reality a process of economic optimization of the inputs with a little bit of a gamble on opportune rainfall. However, for agricultural support personal viewing individual paddies rather than the entire farm enterprise dispersed over several discontinuous parcels, it can be somewhat disconcerting.

Target potential yields for rainfed rice will peak around 5 t/ha in the middle paddies and decline in both directions to around 2.5 t/ha in the deepwater center paddies and to nothing in the upper paddies, if they eventually get abandoned.

Upland rice. Upland rice is produced on 2,047,000 ha or 50 percent of the rice lands of Africa and thus is the most common form of rice production. Normally upland rice is the most difficult and least productive form of rice production. This is largely due to problems of weed control because weed suppression is one of the major benefits of flooding rice. Upland rice, by its nature, has to be treated as one of several cropping alternatives. Thus it will be grown in conjunction with other crops either in adjacent monocultured fields or as intercrops. Plants intercropped with upland rice include maize, cassava, and others in what can be highly complex, interactive, mixed cropping patterns.

Unfortunately, a large portion of upland rice, including most of the upland rice in Africa, is produced as a pioneer crop in slash and burn, shifting agriculture systems which yield approximately 1 t/ha., virtually all of which would be consumed by the farm family. In these areas the initial burning provides approximately one season of weed control. If rice is tried for a second season, the weeds will become overwhelming and the fields will have to be abandoned prior to harvest. Slash and burn agriculture is normally considered environmentally undesirable. Most often it is practiced on steep slopes in relatively isolated areas. The steep slopes allow for substantial runoff and soil erosion with only rudimentary efforts, such as laying the larger logs along the contours made to control erosion. Most development efforts concentrate on replacing rice and the whole shifting cultivation system with less erosive, more stable crops. As this cropping system is considered undesirable, there are no recommendations developed to make it more productive, and the isolated instances of this sytem and low capital availability would make inputs difficult. Most studies of these systems have been more

from the sociological/anthropological side than from the production agronomy side. If there is interest in stabilizing and developing these systems, information should be made available from agro-forestry research efforts.

Under extremely favorable soil conditions upland rice can be reasonably productive and obtain sustainable yields exceeding 4 t/ha each year. This would be on friable, highly permeable soils that allows for rapid nonerosive infiltration of rainfall, and mechanical working of the soil independent of rainfall. In such soils the weeds can be relatively easily removed with minimal disturbance to the rice plants, either manually or mechanically. The most appropriate soils will be the Andepts or Oxisols. They are either young soils derived from volcanic ash or old, highly weathered dark red soils. Both soil types are usually physically stable and thus do not erode even on fairly steep or rolling terrain, Andepts soils commonly occur.

In either case the soils are high in either amorphous material or iron oxides, both of which are highly anion active. Managing anion active soils requires paying closer attention to phosphorus adsorption than cation exchange. The Oxisols usually are highly acidic. However, they may not have a serious problem with exchangeable aluminum, the toxic ion associated with high acidity. Rather they may have weathered to their zero point of charge so that under field conditions they have essentially no charge and thus little exchangeable aluminum. Recommendations for rice production on these soils can be developed. They will most likely concentrate on phosphorus management and require large initial one-time applications of phosphorus or another multivalent anion such as sulfate or silicate. The level will be highly locally specific but will be in the tons/ha range.

Again as an upland system, rice will be one of several crop options that would include intercropping with maize or other annual crops as well as subcropping plantation crops such as coconuts, oil palm, papaya, etc. Agro-forestry research programs should be able to contribute to the development of these systems.

Swamp rice. The swamp rice or deepwater rice is produced on 340,000 ha or 8.3 percent of the rice lands. It includes areas with water depth exceeding 75 cm. Virtually, all of this is in West Africa were it represents 15 percent of West African rice lands. In addition there may a large nearly contiguous area of equal magnitude in southern Sudan with a potential for deepwater rice similar to that of Cambodia, Vietnam, and Bangladesh. Except for the possible large area in southern Sudan, swamp rice would again be part of larger cropping complexes and thus have to compete for operational resources with other crops including rainfed rice. However, swamp rice tends to be a low input–low output crop, which, despite low yields, may represent a relatively good return to the farmers' effort and best land use for those particular fields. Little management that can be done other than preparing the land, sowing the rice, and returning to harvest. The water depth during the season will effectively restrict access to the fields and prevent any midseason managerial inputs such as top-dressed fertilizer applications. Also, the stem elongation to keep ahead of the water depth will result in plants that are too tall for good nitrogen response without lodging, even if top-dressing of N could

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be done. The deep water will also eliminate almost all weeds. Although there is relatively deep water flowing over the fields, the flow should be a nonerosive laminar flow and not cause erosion problems. The after-rice potential for upland crops in the dry season should be good because these lands will have the most residual moisture available.

Research and extension support for rice

The major concern with the research and extension support that African governments provide for rice is to maintain the perspective of rice as a secondary crop in the economy and not provide rice a disproportional amount of the limited resources available for agricultural research and extension. While research and extension programs might be possible to double rice yields, when rice only occupies 10 percent or less of the cultivated lands, this economic gain to the agriculture sector is just not that great. Therfore, there is a need to rationalize carefully the area cultivated to rice, the potential to increase both the area and yields, the need to import rice, and prospects for improving the more traditional staple crops such as maize, sorghum, and millet, into how much manpower and resources should be committed to rice. This is in conflict with the natural desire of all commodity workers to have a full compliment of research and extension staff. The real administrative questions is what is the most appropriate ratio of acreage in rice to research and extension personnel. Certainly Madagascar with 1,000,000 ha and Egypt with 500,000 ha can justify full a research and extension program with all disciplines and subdisciplines.

As acreage and percentage of cultivated lands fall below these levels, reduction from a full staff complement must be considered regardless of the complexity of rice production systems. At 200,000 ha it would be difficult to justify more than on a scientist in each major discipline with that individual covering all the subdivisions. Once acreage drops below 100,000, rice research should be mostly a part-time activity or limited to one or two individuals covering all aspects.

As the level of effort drops, so does the depth of the effort, with a proportional rise in reliance on external collaboration and information sources. For example, if at the 200,000 ha level there is only one scientist per discipline, the varietal improvement effort should not attempt do any actual hybridization of new lines but concentrate on selecting from exotic nurseries such as the INGER nurseries supplied through IRRI, the more specialized nurseries distributed by IRRI's African liaison office at IITA, or other sources of germ plasm. Below 100,000 ha the research effort needs to be mostly verification of networked studies coming from external sources such as WARDA or IRAT.

As important as rationalizing the manpower is rationalizing the level of commitment to the different rice production systems. This is a rationalization over area in irrigated rice vs. rainfed vs. upland and the potential to improve these systems. Unfortunately, there tends to be a concentration on irrigated rice. Part of this is the desire to recover the large capital commitment in constructing the irrigation facilities and getting them working according to the design

expectation, which may have overlooked some of the farmers' upland enterprises. Also, irrigated rice is the easiest and most directly transferable.

A typical example of possible overcommitment of limited resources might be Malawi. With only 1100 hectares of irrigated rice (distributed over 11 small irrigation schemes with a maximum command area of 400 ha, and 37,000 hectares of rainfed rice) Malawi's research and extension efforts are heavily biased toward supporting irrigated rice. There is one small experiment station devoted exclusively to rice research. Most of its program is focused on the 1100 irrigated ha, with only a nominal effort for the 37,000 in rainfed rice. Likewise, a 400 ha irrigation scheme may have 3 or 4 extension workers while the several thousand rainfed hectares surrounding it will have only one. The major extension effort being to get farmers to comply with double cropping rice starting early in the rainy season and completely disregarding the surrounding upland crop or rainfed activities that will delay work in the rice schemes.

Development prospects

As with any crop, the development opportunities for rice are a combination of expanding the area cultivated and the yield per unit area. For irrigated and rainfed rice, the opportunity of expanding area is highly dependent on water resources and a realistic assessment of these resources. For this reason, unless there are some major irrigation schemes, including storage dams, under development, the prospects for increasing the area of irrigated rice is rather limited. Most of the small run-of-the-river systems, while from an engineering perspective they may be operating rather inefficiently, from a practical perspective may be running as efficiently as smallholder systems highly dependent on farmer participation can operate. In appraising irrigations potential there is a tendency to overestimate both the amount of reliable water available (as affected by annual variation in total seasonal rainfall) and the operational efficiency of a system that is largely dependent on farmer's participation. Improving the operating efficiency of the irrigation systems may be possible but might require accepting the interaction with surrounding upland areas and developing some bottoms-up approaches based on farmers' actual rice production practices.

Essentially the same can be said of the rainfed areas. While only 1,000,000 ha of the 10–20,000,000 ha of inland valleys have been developed for rice production, future expansion may be difficult and will have to proceed with care. Each valley will have unique hydrological characteristics that will determine its development potential, which may be difficult to generalize from valley to valley. Many may already have reached their maximum expansion. At least in the broad tracts, the side paddies may already assume an optimistic incident rainfall pattern and not be used every year or may be abandoned after being established if rains are not sufficient to sustain them. It would be normal for considerable annual variation in area cultivated to rainfed rice to reflect the 30 percent variation in incident rainfall from year to year. Moving up the catchment, may seem possible, but this would move into steeper, more erosion-vulnerable areas and may effectively be taking water from the already established lower paddies. As the paddies expand toward the upper portions of the catchment, the

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valley tends to narrow and the paddy size to become smaller. This may hinder the opportunity for mechanization if that becomes necessary or desirable.

The limitation on expanding sustainable upland rice areas will depend on the extent of highly friable soils. It will also depend on the other upland crops in the system and the relative economics of growing each, an economic equation that considers both the commercial and subsistence farming objectives.

Given the generally low yields, increasing rice yields may offer more opportunities than increasing the area cultivated, particularly for rainfed areas. The stability of the irrigated environment as well as the level of transferable research available for irrigated rice makes developing the potential for irrigated rice straight forward. However, given that irrigated rice is already the most productive, the opportunity for improvement is rather limited.

The greatest opportunity for increasing rice production in Africa may be with rainfed rice. The yields are generally low, and amount the of previous research is limited. As with most research programs, varietal improvement is the starting point. The problems, as outlined above, are the need to have sufficient versatility for one or two cultivars to cover the entire rainfed tract and the limited number of researchers that can be reasonably committed to rice improvement.

The need is for cultivars that have sufficient elongation potential to stay above the deep water associated with the middle of the track and enough drought tolerance to do well along the upper edges of the tract. This will require planting nurseries at various locations within a tract and selecting for versatility in the different microenvironments, rather than the best yield for each. This may be in contrast to the typical approach of concentrating on the side paddies which are more accessible for midseason management inputs and data collection. Using side paddies readily picks up some of the drought stress and weed problems, but loses the elongation needs.

Conducting good research and extension on rainfed areas may be more difficult than anticipated. It takes flexible technicians, who can go with the flow of the incident rainfall and microtopology in collecting and analyzing data. The problem is that most technicians responsible for implementing studies, particularly remote farm-level studies, are only technical school graduates without BSc degrees. They are indoctinated to implement instructions as given without question or comment, and they regard any failure to fulfil a set of instructions as personal. However, to evaluate these systems effectively the reasons for the failures are the most important information that can be collected.

Improving the rainfed rice lands will also require close collaboration with an external organization such as WARDA or IRAT for some of the initial selection work suitable to the complexity of the system. IRRI would collaborate in this effort, but would not have much direct contribution. IRRI could also assist with the identification of elongating lines from its deepwater program in Thailand. IITA has already done considerable work in studying the

inland valleys, but it has recently been discouraged from future research work on rice as a duplication of WARDA's and IRRI's mandates.

A major hinderance to development of rainfed rice could be the difficulty in visually perceiving the potential for rainfed rice. It is difficult to describe to someone who has never observed them the beautiful 5 t/ha rainfed rice fields of Asia that stretch to the horizon. Without having personally seen such fields, it is difficult to overcome the impression that rainfed rice is inherently low yielding and requires a tall plant type. The Faya variety in Malawi is nearly two meters tall, forcing one to look up at the panicles rather than down to the waist. However, the perceptions remain that the recommended plant type be tall, for lack of relating to the 1 meter tall lines stretching across the rainfed plains of the Philippines. Thus, before research on rainfed rice in Africa can proceed, it might be necessary for substantial exchanges visits or study tours by African rice researchers to Asia. Such activities could be organized or coordinated by IRRI and the rainfed rice consortium sponsored by IRRI. Some groundwork for this has already been laid by the author of this report.

There is also some potential for improving the sustainable upland rice system. This will again initially depend on varietal improvement. However, the upland varieties do require a slightly different selection effort than paddy lines. This is mostly associated with early seedling vigor and exertion of the root system to provide good anchorage during mechanical weeding while weed control is being obtained prior to canopy closure. Also, to the extent the upland rice is intercropped and subcropped, shade tolerance may be a necessary selection criterion.

In all cases any improvement in rice production will require motivating economic policies and an effective infrastructure supporting rice production and making it a profitable cash crop. Without such policies and infrastructure, farmers will not adopt improved practices regardless of how effective the extension promotions. The situation in Cameroon mentioned at the beginning is an excellent example of how national policy can generate a economic environment that hinders more than assists agriculture sector development. One thing that needs to be considered in developing the infrastructure for rice, or for any other crops in Africa, is the basic limitation of manual farming. There are real limits to how much land a family can manage with nothing but hoes. It is really difficult to work more than 1 or 1.5 ha. Even with only 1.5 ha some parcels will be delayed with associated yield losses. The net result is limited income potential and capital to invest in farm inputs. Thus manual farming will have difficulty becoming more than a subsistence existence.

Another aspect of this is to monitor the rate of adoption of advanced technology. Appropriate technology will usually be rapidly accepted with only limited extension effort. Conversely, if technology is not accepted despite substantial promotional efforts, it is really necessary to reevaluate the technology to make certain it is economically viable. There maybe some subtle aspects that were overlooked and need to be reviewed.

International support

Three international centers supported through the Consultive Group are active in supporting rice research and development in Africa. They include IRRI with a global mandate to support rice research. However, Africa represents the outer limits of IRRI logistical ability to support national programs. With the rather limited acreage compared to the millions of hectares per national program in Asia, IRRI considers the African NARS to be minor clients, even though the clients have committed scarce limited resources to rice production and are seeking assistance from IRRI. Only Egypt and Madagascar have had bilateral contracts with IRRI. IRRI did have a small regional program in Tanzania, but it faltered. They are considering another centered in Mozambique to serve Eastern and southern Africa, but they have not found the necessary donor funding. IRRI needs to develop an approach for working with minor clients with limited staffing and acreage.

WARDA has the best mandate to serve Africa, but it is considered by most to be the weak sister in the CIGAR system. Its mandate, however, is restricted to member countries in West Africa rather than including all of Africa. It should be able to assist with basic research taking over IITA's effort in developing the necessary versatility in rice lines to accommodate the variation in rice microenvironments across the rainfed paddy tracts of the inland valleys. IITA in the past has done considerable work in rice, particularly in the interior valleys. However, the CIGAR has recently encouraged IITA to discontinue its rice work. IITA still provides a base for IRRI's African liaison program. This liaison program does serve all of Africa, but it is limited to coordinating the INGER program on germ plasm exchange. It does compile and distribute several nurseries for use in Africa only, including one on upland rice.

Bilateral assistance for rice in Africa comes from Taiwan and China. Both, operating only in countries with which they have diplomatic relations, have developed some of the small run-of-the-river diversion irrigation schemes. Their programs have lost much of their effectiveness because of language problems. With both donor and host operating in a second language (English), a lot good intentions have been be lost in translation. In Malawi the government finally has just allowed the Chinese Agriculture Mission to do what it likes with little coordination or interaction with the host government. The French through their IRAT research program at Montpelier provide considerable support for rice programs. This is disproportionally provided to Francophone Africa. Included in their rice efforts is a small-scale mechanization program. Finally, Japan through JICA, its technical assistance program, also supports rice in Africa. Each year they fund a six-month training program for African participants. This is held in Egypt in conjunction with the Rice Research and Training Center and concentrates on irrigated rice production. Given that Egypt has 500,000 ha of fairly consolidated, strictly irrigated rice in a subtropical climate, and most sub-Saharan African rice is tropical in relatively small tracts with a strong interaction with rainfed upland crops, the relevance of this training program is questionable.

Late season and postharvest losses

After farmers have worked hard to produce their crop, it is possible for them to lose a substantial amount before they can secure it. Additional losses can occur during on-farm storage or commercial processing and storage. Such losses can amount to as much as 20 percent of the production, depending on the delays in harvesting, the extent of manhandling, and means of storage. All of these can be locally specific. These losses can be divided into late season losses prior to harvest and postharvest losses.

Late season losses. The late season are those losses due to delay in harvesting from the point of maximum yield at physiological maturity to actual harvest. They include losses due to mechanical shattering of the grain and exposure to birds, rats, insects, etc. The main reason for this is that farmers normally delay harvesting for two to four weeks after the crop has reached maturity presenting a necessary but undesirable exposure to these elements. This is done because without good drying facilities, the crop will dry faster in the field than in on-farm storage. Thus the farmers wait until the crop has reached a safe storage moisture content of near 14 percent before cutting, compared with the nearly 30 percent moisture at maturity. A second reason would be organizing the labor force needed to harvest the crop. Even the smallest farmers will hire labor during harvest, and this has to be done in competition with other farmers also interested in harvesting their rice.

To some extent these losses are hard to avoid, although some things can be done to reduce them. Bird damage can be reduced by selecting cultivars with the flag leaf well extened above the panicles. This forces the birds to enter the canopy, where they can no longer keep tract of their surroundings as they would like. The importance of this may be somewhat overlooked by researchers because they normally harvest their crops on time and recommend that farmers do likewise. Thus they are less inclined to notice the extent of bird damage at the farm level. Rats are more difficult to control without developing expensive fencing procedures. The only other alternative is baiting. General shattering has some varietal dependence that is usually picked up in the later stages of a selection criterion, but might well be raised in the selection ladder by some good research on the magnitude of the problem at the farm level.

Postharvest losses. The division between late-season losses and postharvest losses is an arbitrary one, which for the sake of this discussion will be taken as the point the crop is cut. The first losses would be those in handling the freshly cut grain from cutting through threshing and into storage. This is a function of how much handling is done. If small combines, such as those the Japanese are now marketing in Egypt, are used that cut, thresh, and bag, it will be essentially none. However, if the rice is cut, stacked, hauled to the homestead, threshed on the ground with a tractor or animals, sweep up, the losses can be considerable. The only way to avoid these losses is to reduce the handling of the rice by mechanizing the process where possible or by adjusting the organization of the harvesting labor to emphasize rapid field threshing, etc. Estimates in Egypt put handling losses at from 6 percent to 12 percent of the yield, depending on the variety.

Once harvested and stored at the farm level, the losses are in milling and storage. The milling losses are largely a function of the equipment used and how well it can be adjusted to accommodate different varieties of rice. This becomes a particular concern in areas that produce both short-and long-grain rice. Milling tends to be one area with a large public-sector involvement. As well intended as this may be in providing farmers with reliable marketing facilities, the maintenance, equipment updating, and quality control of public-sector mills typically leaves much to be desired. This is one service the private-sector is usually more effective in providing.

Parboiling can increase the milling recoand increase the nutritional value of the milled rice in terms of moving vitamins and minerals from the hulls into the endosperm. However, it normally leaves the rice with some undesirable grain qualities and has to be done under strict quality control, particularly with regard to changing the soaking water, or the rice may acquire an undesirable odor. The increase in nutritional value may be of questionable value overall when rice provides only one sixth of the calories intake of the population. The nutritional importance of parboiling would become more important as the level of rice consumption increases.

Storage losses are mostly associated with insect damage from grain weevils. These weevils get in the grain while in the field and will survive the milling process. This problem has a logarithmic increase over time in storage as succeeding generation of weevils hatch in progressively higher numbers. At the farm level weevil damage can frequently be minimized by bringing the stored grain out and heating it in the sun on some kind of woven mat or shallow wicker basket. The weevils will tend to get away from the heat by seeking the shade under the mat or basket. After several hours in the sun the grain can effectively be rebagged without most of the weevils. If this is done after about three months of storage and thus into the third generation of weevils, it will give good control for most of the off season. In larger, more commercial storage facilities this is not really practical and may require some level of chemical or other means of control.

Impact of the AIDS epidemic

After living in Africa and experiencing the beginning of the AIDS epidemic's impact, including the lose of several close friends and associates, it is difficult to develop a position paper for development in Africa without some reflections on the impact that the AIDS epidemic will have on rice and other sectors of the economy. Conventional wisdom compares AIDS in Africa with the plague that struck Europe in the middle ages. More specifically, if the missionary doctors' prediction that Malawi, with one of the world's highest birthrates, will experience a net 30 percent decline in population, evenly distributed across the urban and rural areas before the end of the decade is true, if the residual population will be mostly children, not reaching a fully productive ages, but dying in their late teens then being cared for by their grandparents in their declining years of productivity, is also true, a manual agricultural society, cannot be unsustained. Thus it might be expected for land to become

more readily available and landholdings consolidated from traditional holdings into estates. However, this will rapidly exceed a holding size that can be effectively worked manually, even if the adults were in their prime-productive years. Thus the agriculture sector may become more mechanized and more commercial. Also, to the extent the AIDS epidemic is disproportionally affecting the black vs. the white African populations, there could be a reestablishment of large white-owned estates.

Under these conditions rice production might easily decline to near extinction. The small rice fields needed for level uniform flooding in the rice tracts will require extensive leveling in order to be enlarged sufficiently to mechanize. In the rice producing inland valleys this would be difficult to do without some extensive cutting and filling that may easily reach bedrock. Thus the rice production will be slowly reduced as will the demand for rice.

Summary

Rice in most sub-Sahara African countries is a minor crop that occupies less than 10 percent of the cultivated area and contributes only one-sixth of caloric intake. However, it is an important imported grain with nearly 3,000,000 tons per year. Rice is grown on some 5,000,000 ha. most of it in small tracts surrounded by upland crops with farmers involved in both rice and upland crop production. This duel farm enterprise system results in farmers concentrating their initial activities on the upland areas prior to establishing the paddy lands. The reason being the extra water in the paddy land provides more time for working in the paddies.

Rice in Africa is grown under highly diverse conditions that include a small area in run-of-the-stream river diversion irrigation schemes, a much larger rainfed area associated with the inland valleys, a large areas of upland shifting cultivation and small area of swamp rice. Expansion of the rice-growing areas may be possible but will require a careful appraisal of available water. Increasing rice yields may offer more opportunity but will require a complete understanding of the interaction with the upland component of the total farm enterprise system as well as the microvariation in cropping potential across the paddy tract. It will also require a favorable economic policy environment and supporting infrastructure.

Support for rice improvement is available from the international centers, but WARDA has the best mandate. IRRI can provide limited assistance, particularly in germ plasm. IITA has worked extensively in rice in the past but is being urged to concentrate on other activities. Any development effort for Africa also needs to consider the AIDS epidemic that is casting a dark shadow over all development efforts for the continent.

Bibliography

FAO. 1992. The rice policy of Senegal. CCP:RI 92/6. Committee of Commodity Problems: Inter governmental Group on Rice, 35th Session. Rome. 6–9 April 1992.

FAO. 1993. Cost of producing rice in Cameroon and recent policy developments. CCP:RI 93/3. Committee of Commodity Problems: Interngovernmental Group on Rice, 36th Session. Rome. 28 June–1 July 1993.

FAO. 1993. World rice situation and outlook 1992–1993. CCP:RI/ CRS 1. Committee of Commodity Problems: Interngovernmental Group on Rice, 36th Session. Rome. 28 June–1 July 1993.

FAO. 1993. Rice exports by destination and imports by origin, 1988–1992. CCP:RI 93/CRS 2. Committee of Commodity Problems: Interngovernmental Group on Rice, 36th Session. Rome. 28 June–1 July 1993.

IRRI. 1985. Rice Improvement in Eastern, Central, and Southern Africa. Proceeding of the Interna tional Rice Workshop at Lusaka, Zambia. April 9–19, 1984. IRRI, Los Baños, Laguna, Philippines.

Izac, A-M.N, M.J. Swift, and W. Andriesse. 1990. A Strategy for Inland Valley Agroecosystems Research in West and Central Asia. IITA, Resource and Crop Management Program.

Table 1. Rice imports and production in select countries of sub-Saharan Africa

Country	Imports 1990	Imports 1991	Imports 1992	Production 1990	Production 1991	Production 1992
	Thousands of Tons					
Angola	49	46	46			
Benin	143	215	261			
Burkina Faso 63	22	35				
Cameroon	80	41	59			
Comoros	42	25	42			
Ivory Coast	216	169	306	660	687	700
Djibouti	23	47	60			
Gambia	61	92	65			
Ghana	80	90	145			
Guinea	98	63	178			
Kenya	57	77	101			
Liberia	73	120	55			
Madigascar	94	70	20	2420	2280	2200
Mauritius	48	41	79			
Mozambique	199	189	118			
Nigeria	6		46	1500	3185	3453
Reunion	20	65	63			
Senegal	365	422	309	156	194	177
Sierra Leone	83	63	48	504	411	420
Somalia	70	57	99			
South Africa	106	263	360			
Tanzania	7	52	57			
Toga	237	141	190			
Others		*349*	*437*	*414*	*2913*	*3251* *2870*
Total	*2569*	*2807*	*3156*	*8153*	*10008*	*9820*

SOURCE: Adapted from FAO circulars CCP:RI93/CRS 1 and CCP:RI93/CRS 2, prepared for the 36th session of the Intergovernmental Group on Rice.

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Table 2. Rice production in sub-Saharan African countries with more than 40,000 ha. in Rice (1980)

Country	Acerage (1000)	percent Land	Yield (t/ha)	Total (1000 tons)
Ghana	80	1.6	0.8	62
Guinea	400	8.1	0.9	350
Guinea Bussau	40	0.8	1.0	40
Ivory Coast	450	9.2	1.2	550
Liberia	197	4.0	1.2	243
Madagascar	1216	24.7	1.9	2327
Mali	190	3.9	1.1	200
Mozambique	75	1.5	1.0	75
Nigeria	550	11.2	1.3	725
Senegal	85	1.7	1.5	130
Sierra Leone	425	8.6	1.3	565
Tanzania	190	3.9	0.9	180
Upper Volta	40	0.8	0.8	32
Zaire	280	5.7	1.3	364

SOURCE: Adapted from Zan, K., V.T. John, & M.S. Alam. 1985. Rice Production in Africa: An overview in Rice Improvement in Eastern, Central, and Southern Africa. IRRI, Los Baños, Laguna, Philippines

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Integrating natural resource management concerns into agricultural research in sub-Saharan Africa: a position paper

by

Thomas M. Catterson

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Executive summary

This paper draws attention to the fact that, despite widespread concern with sustainable agricultural production systems, bringing natural resources management into the agriculture mainstream will require a concerted effort.

Agricultural productivity throughout the region is still hostage to the vagaries of weather and the inherent fertility of the soil. A recognition of the limitations of the resource base will finally turn the development thrust towards a wider variety of sector opportunities while at the same time leading to an intensification of agriculture. Natural resources management must be part of the intensification and diversification trends currently underway.

The present emphasis of NRM in USAID funded projects in sub-Saharan Africa has shifted from a people-oriented, basic needs approach (agroforestry, soil and water conservation, tree-planting) to a more self-serving interest in biodiversity conservation and global warming. It seems unlikely that a strategy to meet these transnational objectives will be achieved if basic needs of the farming populations living adjacent to the protected areas and forest reserves are not met.

Agricultural research workers and those interested in NRM in Africa have common interests. Soil and water, on the farmlands and rangelands of the continent, are the primary natural resources to be managed in this relatively resources poor region. Sustainable farming systems must be considered for what they are—a prima facie instance of natural resources management. Agricultural research achievements which lead to more sustainable farming systems must be counted as significant contributions to natural resource management and sustainable development. Funds used for such purposes should be credited against Congressionally imposed earmarks and program mandates.

More to the point, unless environmental stability becomes a concern and joint undertaking of all concerned, agricultural productivity will not be sustainable. NRM activities widely spread across the farming landscape, reinforcing the watershed function and reversing the pervasive expansion of desertification will meet local, national and international goals. A patchwork of small protected areas—islands in a sea of rising distress—won't lead to the environmental stability on which the destiny of Africa and her peoples is so vitally dependent.

Agricultural research in sub-Saharan Africa must put forward a new paradigm, seeking a highly selective choice of research problems derived from a full understanding of the challenges and opportunities of the resource base. In large measure, the priorities for research and technology transfer must respond to a higher level of input from farmer clients themselves. The decade ahead should see an expansion of farmer managed experimentation (FME) so as to reinforce the vital feedback loop essential to real adoption. Like NRM itself, agricultural research stands to benefit significantly if more farmers are able to fully participate in its planning and execution.

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The technological opportunities implicit in integrating a higher level of NRM into the agricultural research agenda are many. Research must reflect sector policy and plans which in turn can best be built upon a sound macro understanding of land use potential. The vertical integration theme (linking the farmer to the market) now being touted in ag research circles should begin literally at the ground level. Matching land-use to land capability constitutes the most important principle of natural resources management.

Agricultural research approaches with natural resources management as the base brings to the forefront a number of operational opportunities well worth considering. Greater attention to soils management will be fundamental to capturing the benefits of any improved farming practices and to the emergence of modern agriculture in the region. Soil and water conservation will often be possible and recommendable but the challenge will be to find ways to derive incremental benefits from this added investment. A considerable effort will also be needed to put the "agro" back in agroforestry, finding means to integrate trees appropriately in mixed farming systems. Livestock husbandry offers high potential, both as an appropriate land-use as well as an important component in mixed farming systems where its role in nutrient cycling can be critical.

Introduction

Concern with natural resource constraints to agricultural development in sub-Saharan Africa has been a recurring theme for decades. During the colonial period and in the post World War II era, soil and water conservation programs in the East African Highlands were imposed on small-holder farmers by the British and Belgium colonial administrations. Remanent of those efforts are still commonplace throughout the sub-region, as is a now gradually abating resentment and backlash among farmers to their imposition. Sahelian agricultural research programs considered soil degradation an issue in the 1920's (Reardon 1994). The fragile base for dryland agriculture was a key theme which launched the CILSS and the Club du Sahel, and their paramount program, "La Lutte contre la Desertification," after the devastating Sahelian drought of the late 60's/early 70's (DeLattre and Fell 1984).

Despite this abiding heritage, much remains to be done in putting agricultural research on a sound, natural resources-oriented footing from whence it seems likely to be able to increase its contribution to regional development.

Purpose and objectives of this position paper

The overall purpose of this paper is to contribute an overview of natural resource management (NRM) based perspectives to the design initiative for the Sustainable African Agricultural Technology Systems (SAATS) Project. The SAATS project is intended to "enhance and promote the development of effective, sustainable agricultural technology systems that will improve the welfare of Africans through the development and transfer of sustainable and profitable technologies." SAATS is expected to result in "improving food security of consumers, increasing the incomes of households, firms and the nation," and "sustain and improve the quality and productivity of the natural resource base in Africa" (USAID 1994).

This paper will focus attention on objectives which can be achieved by further integrating NRM concerns into the agricultural research agenda in sub-Saharan Africa, to wit:

- ensure that the issue of sustainable farming systems and agricultural technology is based on sound NRM techniques aimed at reversing the on-going ecological degradation troubling the productive lands of the region;

- incorporate NRM considerations vital to alleviating the slow growth of productivity in the agriculture sector; and,

- provide NRM guidance that can help the important process of filtering agricultural research priorities and themes which SAATS can and should address.

Present agriculture sector trends

Agricultural productivity throughout the region remains today still highly vulnerable to the vagaries of the weather and the inherent fertility of the soil. Africa still figures as the predominant worldwide destination of food aid, both for relief purposes or food-for-work programs. The shift of the rainfall isohyets and continuing spotty temporal and spatial rainfall patterns in the Sahel and their impact on rainfed agriculture have shattered national plans aimed at "food self-sufficiency," a theme that figured vividly in the policies of the post-independence states. Both the Horn of Africa (including the Sudan) and Southern Africa have experienced similar phenomena.

Soil degradation and erosion have been no less of a problem, contributing to the pervasive loss of both per-capita and per-area food production achievements in many countries. In Uganda, Rwanda, Burundi and parts of Kenya and Tanzania, population pressure is increasingly pushing farmers onto even steeper lands and diminishing the size of the already micro-farms. Throughout the northern Sahel, beyond what was once characterized (typically on colonial era maps) as the "northern limits of cultivation" and once thought of as grazing areas and pasture reserves, subsistence farming is expanding onto highly marginal areas. Clearing these brushlands and savannahs for millet farming has devastated large areas and forced livestock herders to further overgraze the remaining areas. Large-scale mechanized farming below the 600 mm. isohyet in the Sudan has created desert-like conditions with little likelihood of natural fallow leading to rehabilitation for years to come.

Agriculture remains the "engine of growth" for most sub-Saharan African countries but the motor clearly needs the major overhaul both this project and many other sector development actions intend. Per-capita food production is now lower than it was in the 1980's and growth in the sector has averaged about 1.4 percent from 1970 to 1985, as compared with sector growth of 2.7 percent in the 1960's (World Bank 1989). Drought in the 70's and 80's has played its part, but many farmers in both the arid areas and the better watered zones are also facing the limitations imposed by degraded soils. Farming strategies evolved to meet the vagaries of weather, pests and markets are being circumscribed by soil degradation and shorter fallow periods which limit the possibility of using mixed cropping farming systems specifically put in place to provide a margin against these inherent risks. Governments and their donor partners have coined the new term "structural food deficit areas," meaning areas where the inherent resource limitations and current technology and market options make it next to impossible to feed the burgeoning populations resident there.

It is this very crucial understanding of the limitations of the resource base that sparked the major shifts that took place with the Industrial Revolution in the United States and Europe, and which is still going on there. For example, in New York State, dairy farming is a difficult enterprise given the present market circumstances if you do not own 500 acres of the best land, utilize the latest technology, have a healthy, highly productive herd, and increasingly, send your spouse out to work! It is clear as well that such a transition is underway, albeit in only nascent ways, in many countries of Africa.

Increasingly, farm households are looking to off-farm income generation opportunities to bolster their farm based income and food security. Indeed, Reardon (1994) concluded that in the Sahel, "Overall income is much more important determinant of household food security than is cropping alone."

In the past, migration to the towns, cities and other countries by part of the household served to generate remittances for the household budget. Many farm families are now also looking for income earning opportunities closer to home, as traders and in retail sales, by providing village services (blacksmith, baking, cereals transformation, and even in other more sophisticated enterprises).

Population pressure is also slowly convincing farmers themselves to intensify the level of their farming systems so as to produce more on the small pieces of land under their control. The latter has been characterized by a turn towards more modern agricultural approaches, especially the addition of agro-chemicals, animal traction and crop diversification. Purchasing agro inputs remains a challenge to many because of price considerations and limited access. Sound natural resource management practices will, inevitably, become part of the intensification of agro-systems.

Important externals—now rising to the surface

There is neither scope in this paper nor reason to rehearse the full panoply of political, social and economic constraints which have previously undermined the development of more productive, remunerative and sustainable agriculture in the region. (1) New insights into getting agricultural and resource tenure policy right and better linking the developing farm economies to the marketplace are essential elements of today's "Africa in Transition" (USAID 1993), and will also meet NRM needs. More participatory and genuinely representative forms of governance have set the region on the road to peace and stability, not, however, without the likelihood of small and large bumps along the way (witness the current tragedy in Rwanda). The corollary must also be stated, that obviously peace, stability and justice cannot be built on the basis of good natural resources management alone either.

Past efforts at NRM related to agricultural development

The perceptive reader will not fail to point out that many natural resources management activities, often in large and impressive sounding programs and projects, have been incorporated into the pantheon of rural development in sub-Saharan Africa since the early 1970's. Why then has the track record with projects of this nature been so lackluster (this the opinion of the author who himself has been involved in trying to design and implement NRM activities in Africa for over 15 years!)? The answer appears quite simple; the farmers know better. There are two perspectives to this paradigm of the knowledgeable farmers.

On the one hand, farmers often realize the inherent limitations of their agricultural resource base and understand that additional investments required for adding conservation practices are

unlikely to find resonance in today's marketplace. To put it bluntly, they do not see or wish to envisage their destiny linked to their meager share of modestly productive natural resources—land and water. Rising expectations instigated by the widening gap between rich and poor have undercut the notion that subsistence farming is a way of life to be aspired to, even under conditions where achieving that limited goal is almost always beyond one's means.

On the other hand, looking at the cases where projects or programs have led to a substantial positive change (of which there are certainly many examples although they tend to be both modest and localized) would probably reveal that these more successful initiatives have been heuristic rather than prescriptive. The implementing organizations responded to what the farmers were telling them instead of trying to force a preconceived technological package on them. An excellent example of the latter case is the Burkina OXFAM Agroforestry Project where the farmers explained to the project manager that they were more interested in water catchment basins than agroforestry. Because the project manager listened and OXFAM was flexible, the project turned into one of the most successful soil and water conservation initiatives in Africa. Ten years later, the practices developed on the Yatenga Plateau have spread to thousands of hectares of farmland in Burkina, Niger and Mali (McGahuey, personal communication).

Livestock husbandry and range management—still a major challenge

Another major contradiction in the broad arena of the interplay between agriculture and natural resources management is the present situation of the livestock subsector. Despite the importance of livestock as a common element in African farming systems, little has been accomplished in this subsector from an NRM perspective. Many large-scale and well intentioned livestock projects floundered in the past. There is presently a decided reluctance among the donor community to fund new efforts of this type, doubtless fueled by the now numerous instances of political strife swirling around herder peoples across the region.

The situation is also in sharp contrast with the well-founded belief, shared by many, that livestock husbandry offers Africa a comparative advantage given its predominantly arid and semiarid agroecosystems. Similarly, the role of livestock in mixed farming systems in many parts of the region can, if properly managed, bolster elements of the farmer's own natural resources management strategy.

Natural resource management —"Quo Vadis"

The development community should carefully reflect on the recent directions of support for natural resource management. Funding and support for NRM remains high and vibrant, fueled by relatively new realizations that localized environmental degradation can have transnational if not global implications. The concerns about biological diversity and the need to halt the tropical deforestation contributing to global warming are no doubt valid. Significant amounts of NRM-earmarked funding have flowed to these issues over the last five years.

A remarkable shift in funding directions, however, seems to have taken place since the beginning of the decade. The conviction that small-holder focused programs and projects aimed at soil and water conservation, agroforestry, farm and community forestry which characterized a vibrant commitment to people-oriented programming during the 1980's has lost momentum with little justification—a particularly egregious example of the "trendiness" so common to development programming. Whether protecting small natural areas or controlling deforestation can make a difference either for development or conservation, however, remains an open question.

Biodiversity conservation and halting tropical deforestation are topics of only peripheral interest for the farm families of the region struggling to meet their food needs and discern a destiny beyond abiding poverty and a fragile hold on a subsistence existence. Soil and water, primarily on the farmlands and grazing lands of the continent, remain the most important elements of the challenge to natural resource management and sustainable development in sub-Saharan Africa. Protection and tree-planting seem destined to have only an ephemeral and transitory effect if basic needs cannot be met. They will quickly be overwhelmed by the inexorable pressures of a disenfranchised peasantry seeking, justifiably, to meet their basic needs.

Simply stated, agricultural research achievements which lead to more sustainable farming systems must be counted as significant contributions to natural resource management and sustainable development. Funds used for such purposes should be credited against Congressionally imposed NRM earmarks and mandates. More to the point, unless environmental stability becomes a concern and joint undertaking of all concerned, agricultural productivity will not be sustainable. NRM activities widely spread across the farming landscape, reinforcing the watershed function and reversing the pervasive expansion of desertification will meet local, national and international goals. A patchwork of small protected areas—islands in a sea of rising distress—won't lead to the environmental stability on which the destiny of Africa and her peoples is so vitally dependent.

NRM-based off-farm income earning opportunities

In a related way, natural resource management based income earning opportunities may offer the most viable way to supplement the household economy and thus enable farm families to better survive while attempting to make their farming practices more sustainable. Farm woodlots can meet family needs, provide crop site enhancement through climate amelioration and soil improvement (windbreak effect, addition of organic matter from leaf fall) while at the same time offering a product for sale on the local market.

The emergence of large-scale natural forest management in the forests, woodlands and brushlands of the region provide the opportunity for creating a vocational outlet for small farmers. They may be able to turn their energies to making a livelihood by participating in these management and utilization plans and activities and suspend their non-sustainable farming practices. Managing small patches of forest in areas well suited for them across the

landscape adds an element of environmental stability to the local area—through an enhanced watershed function and broad ranging climate amelioration, both supporting agriculture.

In other areas, the lands being farmed would be more productive and sustainably managed if there was a major shift in land-use, such as a shift to fuelwood and pole production. As mentioned above, this may happen eventually anyway because of degradation, abandonment and rehabilitation. Why wait until the last minute to begin making the transition to a productive activity more suited to the capabilities of the site?

The meaning of natural resource management

Natural resources management is viewed as a process by which people (men and women) are able to satisfy their contemporary needs and just aspirations (food and a livelihood) without significantly foreclosing the options for the use of these same resources by future generations. The qualifier, "significantly" is essential here, because tradeoffs are more often than not necessary over the near to medium-term. Certain elements—land capability constraints, technology, fair markets and social inequities—make it difficult to achieve the full measure of compatibility between development and environmental stability. Others would argue that it is inevitably a question of give and take as new technological discoveries and changes in the socioeconomic framework make it possible to alter these basic relationships (Catterson et al, 1993). A basic premise of this paper is that incorporating natural resources management as an important principle of agricultural technology development means increasingly seeking as a start to better match land-use to land capability.

The term "natural resources management" has become something of a cliché in development circles, justifiably so given the increasing concern about man's dependence on the increasingly threatened environmental stability of the planet. Indeed, an element of "green conditionality" has become part of on-going, donor-driven development programming objectives. There is certainly a need to be very realistic about how far one can go in manipulating the site conditions to achieve agricultural productivity. The corollary, however, is the need for caution about objecting to the inherent reality of current land-use patterns and the time it will take to adjust them to something more in balance with nature.

For example, one could argue that almost all cereal production with conventional farming methods leads to some form of site or soil degradation, whether from erosion, nutrient leaching or depletion, or the residual effects of the use of agrochemicals. But it should be important as well to realize that the debate is not and cannot be "environment or growth;" this is an inherently futile argument, especially in the application of environmental management principles to agricultural research. It is also very clear that the current objectives of the natural resources and environment sector so much in vogue will not be met if basic needs for food and a livelihood are not generally satisfied in the rural areas surrounding the protected parks and forest reserves. The community needs to face the reality that in Africa, women and men are the most endangered species, and until they themselves think otherwise, biodiversity will continue to be threatened.

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Some basic axioms

There are some broad principles associated with incorporating more natural resources management into the agricultural research agenda. Many are well known and understood, often to the point, however, of being lost in the background noise of the increasingly strident, albeit well meaning, demands and needs for either food security or environmental stability. They are noted here.

Population

Since the 1960's, the population of sub-Saharan Africa has doubled (to approximately 500 million) and population growth rates on average remain the highest in the world. The World Bank (1989) projects the continent's population to rise to well over a billion people, even under more modest growth rates, by the year 2020. In many countries, the age structure with a predominance of young people, especially young women bound to produce children, already indicates that measures to bring population growth under control will be very difficult (Shaikh 1993). (2)

Population is the first element of the NRM equation. A number of emerging patterns related to population growth are of interest here. On the one hand, it has been noted that "growing population pressure, on marginal lands, did not always produce increased rates of (environmental) degradation. In a number of sites, intensification was greatest on marginal land in areas of high demographic pressure. In some cases, people simply ran out of options (the "end of the frontier" had occurred) and, in other cases, a greater population increased market opportunities that made intensification more attractive (McGahuey, personal communication).

On the other hand, it has also become undeniably apparent that many of the NRM focused development programs and projects aimed at land rehabilitation and soil and water conservation, effectively can only be viewed as "buying time." A greater array of socioeconomic development opportunities, including access to more productive and sustainable agriculture technologies, as well as off-farm employment must come into play, allowing rural people to seek their destiny beyond the farm.

The other dramatic trend is urbanization. Increasingly, Africans see their future in the growing cities of the region. Migrants from the over-populated, degraded marginal areas will be attracted to the prospects of jobs and social services in the urban areas, whether these are real or imagined. Urbanization should not be discouraged; it will draw people off marginal lands. It will also lead to more modern societies and promote greater industrialization and a service industry thereby creating a widening cash marketplace for the food and other products of the farm economy.

Institutionalizing subsistence farming?

As the above discussion highlights, many development programs and projects aimed at land

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rehabilitation and soil and water conservation must be seen as buying time. The question is what is being bought and where are the programs heading? There is a profound need for a well-conceived vision of the future of the agriculture and natural resources sector (starting with the conviction raised above, that good agriculture is natural resources management) in many countries of the African region. In addressing the policy choices for rural development, one must have a vision of the continuing evolution of land-use and agricultural development.

The policy agenda must "get ahead of the curve." A challenge to the policy makers and sector professionals, including agricultural research staff, is to ensure that timid or minor changes are not simply reinforcing the "status quo" and postponing the inevitable crash of a subsistence-based rural economy—with the likelihood that both the natural resources degradation and social disintegration it brings will be more extreme and more difficult to remedy (Catterson 1993).

Subsistence farmers unable to achieve more than marginal gains in productivity, however sustainable, because they cannot afford the added costs of inputs on their inherently poor lands will not be able to feed the future population of their household or village. In many parts of sub-Saharan, rural migration has so eroded the labor base that implementing the full set of soil and water conservation and improved farming practices (most of which tend to be labor intensive) even on better lands, cannot be accomplished with the labor available within the household. Then too, subsistence farmers are well known for being "risk adverse." For example, millet farming has expanded across many of the marginal areas of the

Sahel. Despite existing knowledge about banding, contour farming and improved spacing, few farmers utilize these techniques. This is often explained away as the result of labor shortages. In fact, it may well be a function of farmer attitudes about millet farming. It is in many cases, the crop of last choice as soil fertility and soil organic matter bottom out in a declining spiral of farming options. It too brings risks—from erratic rainfall, infection with the parasitic weed Striga spp., and depredation by the graining eating birds common in this agroecological area. Good production years may glut the market, drive down prices and thereby offer only marginal returns, hence the reluctance to invest, either cash or labor.

These paradigms have not been lost to the farmers. Their reluctance to invest may be a common sense reaction to the futility of the meager returns to agriculture, eking out a living on poor lands. As mentioned above, their energies may be channeled increasingly into diversifying their income opportunities or, disturbingly, a fatalistic response to the inevitability of it all, especially after having suffered through a promising development project or two.

Cost effective NRM

In short, sector specialists need to be wary of their efforts whose impact may result only, or at best, in "institutionalizing subsistence farming." The agricultural research agenda focused on the future will have to make some distinctions in setting priorities and visualizing its clients—whether to aim at building resilience into viable yet vulnerable small holder farming

systems or directing its efforts towards sustainable sector modernization. In many countries, an emerging cadre of bigger, more innovative farmers will begin to accumulate more land. Investment oriented farm enterprise development should be directed at better lands where both the productivity and returns to the farmer are likely to be highest.

A third group of households will fall between the cracks, namely those without either enough land or good land to feed themselves without degrading the site. In many cases, the consequences of their poor farming practices are seen and felt off-site, ecologically as erosion, siltation, flooding and disrupted water supplies, and socially, as disintegrating rural systems sending environmental refugees to the cities. For each of the above three general tiers, agricultural policy and research must define its strategies and tactics.

Agricultural research approaches with NRM in mind

The common denominator in the three-tiered (3) approach to agricultural policy and research discussed above, are the natural resources capabilities and limitations of the land held by the farm family. Too many agricultural research initiatives, reflecting the success of the "Green Revolution" in other parts of the world, focus first on varietal improvement of the crop species. Soils management must be the primary consideration for ag research. There seems to be little likelihood of capturing the real benefits of "modern agriculture" without it.

An NRM focused agricultural research effort will spend more time working with the elements of the agroecological equation, man and his resources and how he/she uses them, rather than focusing exclusively on the outcome of the combination of land and labor, i.e., the crop. Taking these natural resources conditions into account can be an important first step towards identifying ag research priorities and potentials.

Vertical integration and land-use planning—good NRM

It is now thoroughly recognized that agriculture policy should ensure that agricultural research endeavors and achievements link the farmers to the marketplace. The natural resources base can provide policy makers with the basis for beginning their analysis of productivity and directions for development and provide an order of magnitude vital to understanding sector production and marketing potentials. This macro overview that can be obtained by the relatively simple technique of preparing a land capability map and comparing it with a actual land-use map, can act as a first filter for setting agricultural research priorities. The land-use planning exercise also provides the baseline for understanding the full variety of the mosaic of land use choices in a given area and how they might be better integrated to foster a more sustainable local farming system. (4)

For example, if the government had even rough calculations of the area suited for pastoralism and its productive potential, it could analyze more succinctly the costs (individual and social) associated with allowing or even inducing sedentary agriculture in such areas. It could also estimate the costs of the breakdown of the pastoral societies in social and ecological terms.

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A greater capability with land-use planning can also be used to foresee major shifts in land-use patterns. Degraded upland areas may be common throughout a particular watershed or administrative area. Some land-use planning capability should be a part of the agriculture and natural resources research systems, perhaps assisted with new technologies such as Geographic Information Systems (GIS). These capabilities should form the quantitative foundation for the establishment of sector policies and plans and the choice of agricultural research priorities to achieve them.

The shift from a commodity based approach to one more geared to the farming systems needs and opportunities and the natural resources base on which they are founded should be the first step in integrating NRM into agricultural research. Research should begin by seeking to better understand the set of agroecological conditions, then finding production options for them rather than seeking to transform the local conditions to meet the needs of a commodity or crop. Once a reasonable match in ecological, social and economic terms has been identified, one can begin a program to find technological methods to improve productivity incrementally.

For example, a major challenge to agricultural research on the African continent will be to factor in the ecological and social changes resulting from atmospheric climate fluctuations (Pielke 1994).

Defining agricultural research priorities by region

Commodity and crop focused research networks are common in the agricultural research world. The NRM approach to agricultural research suggests that networks should be focused on the principal agro-ecosystems and the constraints they each face. The following constitutes a quick synopsis (5) of the accepted agro-ecosystems and their most salient NRM related constraints or problems:

- West and Central Africa Humid Tropics—soil fertility losses and leaching under cereals .
- Subhumid West Africa—soil nutrient deficiencies, tsetse and labor shortages.
- Sahel and related drylands—erratic rainfall and fragile soils.
- Savannah zone of East and Southern Africa—limited and unreliable rainfall.
- East African highlands—small size farms and erosion potential.

Technology choices and directions

On a much more tangible and field oriented basis, a number of technological choices and their iterations have started to take on significance as trends in utilizing NRM in support of agricultural productivity and sustainability. These should continue to be explored as part of

sustainable farming systems by agricultural research entities and programs for sub-Saharan Africa. Accordingly, they need only be mentioned in passing here; they include:

- no-tillage agriculture
- improved crop spacing and intercropping combinations
- green manure
- compost pits
- soil engineering based soil and water conservation and water harvesting
- live fences and vegetative erosion barriers (hedgerows)
- fodder/fuelwood banks on marginal land or as an improved bush fallow system

Participatory agricultural research—FME

Participation has proved to be vital to achieving real success with natural resources management in sub-Saharan Africa. Taking the above approach, basing ag research priorities and programs on agroecological conditions and potential impact must be tempered by the priorities imposed by real life. The professionals and scientists will identify a plethora of promising production options, keyed to their own special interests, to fit particular agroecological niches. This will quickly spread their capabilities too thin to achieve impact. This was the error of integrated rural development projects—seeking to be all things for all people. Agricultural research in sub-Saharan Africa cannot afford to make the same mistake.

As scientists and technologists, however, they are duty bound to collect evidence on the most promising combinations. Genuine participation with farmers (especially with women whose role as farmers in Africa is as or more widespread than that of men) themselves should be sought, seeking out the innovators as informants about promising technologies and pressing constraints. Combining farmer managed experimentation (FME) with on-station research allows for a period of test marketing and fine tuning of the research findings. The dialogue essential to the relationship between researcher and farmer can add vital information to the perception of the client's needs and opportunities.

This FME approach, involving frequent and regular visits to farm sites by research personnel is the best basis for understanding the social and economic circumstances farmers confront on a day by day basis. Seen from a distance, it is too easy to misconstrue their motives or chastise local people for not optimizing their farming choices. Contact will promote familiarity and open channels of rapport, communication and understanding for which there is no substitute (Catterson et al. 1991).

Livestock and nutrient cycling

Livestock plays a formidable role in African farming systems. (6) In addition to providing food and products of value to the household either for direct consumption, sale or barter, animals have long served the African farmer as a tool for harvesting and converting scarce nutrients essential to crop yield.

Because of increasing human and animal populations, this very useful synergism is threatened in many parts of the region. In more sedentary farming areas, finding grazing and refuge for the animals during the crop season is an ever more difficult challenge. At the pastoralist/farmer interface, for example along the southern fringe of the Sahel, political tensions and perceptions have engendered conditions leading to localized mini range wars (Tchiwanou and Heermans 1994). Managing animal numbers in relation to carrying capacity of the farm cum rangelands has never been an easy proposition, fraught with difficulties because of the need to overcome resistance to animal off-take. Despite these constraints, it is an important road sign on the crossroads of agriculture and natural resources management and one in which the right path is likely to lead to significant benefits for all concerned.

Economics, NRM, and agricultural research

It is well understood that to a certain extent, one can "push the envelop" in terms of land use/land capability match by applying improved farming and soil and water conservation techniques. These techniques add costs to the production equation. Farmers are by long experience rational financial managers; they understand that if the costs of production exceed the potential benefits, they will be the losers. It also seems plausible to assume that farmers will want more than just marginal returns, especially after years of promises and waiting. One cannot achieve conservation on the backs of those least likely to be able to afford it.

Agricultural research should endeavor to avoid the trap in which many development projects have fallen—increasing production costs as a first option while operating in a marginal marketplace. This is a common occurrence when resource wealthy research approaches are conceived for resource poor farmers. In a similar vein, the analysis of the costs and benefits associated with agricultural research often fail to take into account the real costs of ecological degradation. (7) Economic analysis confined to estimates of productivity will fail to identify the real costs of unsustainable farming systems. Then too, rehabilitation afterwards is much more costly than preventing degradation.

Are conservation incentives needed?

The economics of NRM in a farming setting may point to the need for either increased investment or production tradeoffs. Protection, in the form of fallow or for grazing control with livestock programs requires farmers and herders to accept short term measures with long term goals. Labor to meet sustainability objectives may no longer be available to supplement the household income with off-farm earnings. In the meantime, will the farm family be able to survive?

There is little likelihood that the Governments of the African countries where conservation is most needed could afford to mount an ambitious program of conservation incentives. Nevertheless, similar programs have been responsible for helping to reverse environmental degradation and/or buy time for a wider variety of production options for farmers throughout the world. Although the current resistance to such programs is based on the recurrent costs

dilemma they might engender, the real question should be viewed as an issue of incentives to investment or subsidies. If farmers understood that a conservation incentive represented a justifiable (because of off-site consequences of ecological degradation) government investment, intended to have real returns, they would grow more willing to make similar investments themselves.

Similarly, where the production tradeoffs necessary to reach sustainability are significant, the state (and its donor partners) should seriously consider a rational conservation incentive program. In this vein, it seems likely that a great deal could be done with program food aid now used extensively for food-for-work for NRM activities throughout the region.

Agrochemical use and NRM

Agrochemical use is presently so limited in Africa that it does not constitute a serious source of non-point pollution, except under rare conditions and with certain crops (eg., cotton). The use of agrochemicals, however, seems bound to expand in the near term and a number of NRM related points are worth keeping in mind.

For one thing, agrochemical use is both more effective and efficient under conditions of reasonable soil quality. C/N ratios and soil organic matter can have a dramatic effect on the results of fertilizer use. On the other hand, as farmers confront the new cost structure for the use of agrochemicals resulting from recent shifts in exchange rates and continuing low availability of these inputs, the potential for integrated pest management (IPM), a genuine NRM based system, becomes more attractive for both financial and ecological reasons.

Notes

1. An excellent discussion of this topic may be found in the publication, *Towards a Sustainable Future for Africa,* prepared by the Office of Analysis, Research, and Technical Support, Bureau for Africa, USAID. Technical Paper No. 5, Washington, D.C., April 1993. For an even more in-depth analysis of the topic development constraints and opportunities for sub-Saharan Africa, consult the World Bank publication— *sub-Saharan: From Crisis to Sustainable Growth,* prepared in 1989, Washington, D.C.

2. This interesting presentation by Dr. Asif Shaikh includes an excellent discussion of population growth and its implications for the environment and development. See Shaikh, A. *Managing Change: The Population, Environment and Development Nexus in the Sahel,* International Resources Group, Ltd. Washington, D.C.

3. In many African countries, one could envisage a set of circumstances that enabled the classification of more than three tiers of resource limitations and capabilities. For example, in a country with both highlands and arid lands, additional distinctions would be appropriate and useful in devising agricultural policy and research strategy.

4. A good deal of preliminary work, both at the regional level and in certain countries, has already been undertaken on agroecological zonation so this effort need not begin at ground zero. See for example the publication: *Report on the Agro-Ecological Zones Project, Vol. 1- Methodology and Results for Africa,* FAO World Soil Resources Report No. 48, Rome, 1982.

5. A number of studies have attempted to define agro-ecological zonation and the NRM relevant constraints farmers face in each. It would be advisable to consolidate this information and collate it before embarking on further studies of this kind. Among the publications which could form the basis for such networking are: the aforementioned FAO study on Agro-Ecological Zonation for Africa, the comprehensive analytical study prepared by Peter Freeman as a prelude to the AID/AFR Plan for Supporting Natural Resources Management In sub-Saharan Africa, and the landmark study by Shaikh et al, *Opportunities for Sustained Development: Successful Natural Resources Management in the Sahel.*

6. This important topic was the subject of a major conference convened by the International Livestock Center for Africa in Addis Ababa in November, 1993. See the Proceedings (in press) for the Conference: *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa.*

7. An interesting discussion of this topic can be found in the publication *The Off-Site Costs of Soil Erosion,* by Thomas E. Waddell, Editor, Proceedings of a Symposium held in May 1985, The Conservation Foundation, Wash. D.C.

Bibliography

Brinkerhoff, D.W., Gage, J.D. & Yeager, J. 1992. *Implementing Natural Reources Management Policy in Africa: A Document and Literature Review.* Prepared for AID/AFR/ARTS/FARA. MSI/ IDMC/Abt Associates. Washington, D.C., April 1992.

Catterson, T., Wilson, W., Gavian, S. & Adoum, C. 1993. *Natural Resources Management and Program Food Aid in Niger: An Initial Analysis of Linkages.* USAID/Niger, Agricultural Policy Analysis Project, Phase II. Abt Associates, Inc. Bethesda, Maryland and Niamey, Niger. March 1993.

DeLattre, A. and Fell, A.M. 1984. *The Club du Sahel—An Experiment in International Cooperation.* OECD. Paris.

ICRAF n.d. A Search for Alternatives—A *Global Initiative to Find Viable Alternatives to Unsustain able Slash and Burn Agriculture.* Nairobi.

ICRAF 1993. *ICRAF—A Global Agenda.* Nairobi.

ILCA 1993. *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa (Abstracts).* Conference Proceedings. Addis Ababa, Ethiopia.

Rochette, R.M. editor 1989. Le Sahel en Lutte Contre La Desertification—Lecons d'Experiences. CILSS/Programme Allemand CILSS (PAC), Eschborn, Germany.

Rodale Institute Research Center 1993. "International Ag-Seive—A Sifting of New About Regenera tive Agriculture," Vols. 1–5, 1988-1993 (combined bound edition). Kutztown, Pa.

Pielke, R. 1994. *Don't Rely on Computer Models to Judge Global Warming.* "The Christian Science Monitor," Vol. 86, No. 190 (Wednesday, Aug. 24, 1994), p. 19.

Shaikh, A. and Snrech, S. 1992. *Managing Change—The Population, Environment and Development* Nexus in the Sahel. International Resources Group, Ltd. Washington, D.C.

Shaikh, A., Baldwin, M. and Catterson, T. 1994. *Natural Resources Policy Analysis Agenda.* USAID/Gambia Agriculture and Natural Resources Project, International Resources Group, Ltd., Washington, D.C.

Tchiwanou, M.B. and Heermans, J. 1994. Les Fulbe Eleveurs Face aux Nouvelles Strategies de Gestion Participative des Ressources Naturelles au Benin. Ministere du Developpement Rural, Projet de Gestion des Ressources Naturelles. Cotonou. Avril 1994.

USAID 1993. Towards a Sustainable Future for Africa. AID/AFR/ARTS Technical Paper No. 5, Washington, D.C. April 1993.

USAID 1994. *Proceedings of the Agricultural Technology Development and Transfer Collaborators Workshop.* AID/AFR/ARTS/FARA, Washington, D.C.

USAID 1994a. Strategic *Framework for Agricultural Technology Development* and Transfer in sub-Saharan Africa. AID/AFR/ARTS/FARA Technical Paper, Washington, D.C.

USAID 1994b. Strategies for Sustainable Development. U.S. Agency for International Development, Washington, D.C., March 1994.

USAID 1994c. Agricultural Research in Africa—A Review of USAID Strategies and Experience. AID/AFR/ARTS/FARA Technical Paper, Washington, D.C.

Waddell, T.E. 1985. The Off-Site Costs of Soil Erosion. Proceedings of a Symposium held in May 1985, Conservation Foundation, Washington, D.C.

World Bank 1989. *Sub-Saharan Africa: From Crisis to Sustainable Growth—A Long-term Perspective Study.* Washinton, D.C. 1989.

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Project design team output: economic report

by

James Oehmke

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1. Background and introduction

This document presents the results of analysis conducted to help define achievable targets for the SAATS Initiative, to be incorporated into a logframe for the SAATS Initiative. In the course of the design, it will be necessary to define the goal, subgoal, purpose, output and input levels and measurable targets for them (PARTS Project Amendment Design, p. 14).

The document will proceed by addressing each of these target levels in turn, in the next section. The economist is also supposed to provide some broad input on socioeconomic issues, and on guidelines for programs and priorities to be included in SAATS. These issues are addressed in the third and fourth sections, respectively.

2. Analysis to define targets

2.1. Goal and target

2.1.1. Goal

The strategic goal for the SAATS Initiative is sustainable, broad-based, and market-oriented economic growth.

This goal is taken directly from the AFR/SD objective tree for the agriculture and natural resources (ANR) sector. The close relationship between increases in aggregate measures of economic performance, such as gross national product (GNP) or per capita income, and indicators of individual welfare is well documented. For example, longevity rates, per capita food availability, and indicators of personal health are positively correlated with per capita income. Child mortality, disease, and malnutrition are negatively correlated with income. Such indicators show evidence of the lack of broad-based growth in sub-Saharan Africa (SSA): the infant mortality rate of 99 is among the world's highest, and 30–45 percent of the children under 2 were significantly underweight in the six countries for which data are available (GHIA). Consequently, stimulating sustainable economic growth is likely to cause significant improvements in individual welfare.

Economic growth also contributes to broad social goals. For example, civil stability and the workings of democracy are facilitated when people have access to adequate employment or other income generating opportunities. For example, in East Africa "social stagnation is partly explained by the slow and insufficient growth of the economic and of productive employment (ASARECA, p. 7)." Economic growth increases in governments' abilities to make investments in physical and social infrastructure, educational services, and other socially desirable activities.

The goal contributes directly to the Agency target area of economic growth, and contributes collaterally to improved health through increases in the quantity and quality of foodstuffs supplied, to democracy through the empowerment of Africans in research management, and contributes directly to technical solutions to natural resource issues.

2.1.2. Target

The relevant target for African economic growth is 4 percent per annum. Given population growth rates of about 3 percent per annum for a number of sub-Saharan countries, the 4 percent target is a minimum requirement for generating a significant increase in the welfare of the next generation of Africans. Rates of growth exceeding 4 percent, while laudable goals, are difficult to obtain and nearly impossible to sustain. The choice of 4 percent is also consistent with World Bank analysis of African development (e.g., Cleaver and Donovan).

As with all targets presented in this paper, the underlying analysis is rife with generalizations,

and the diverse nature of SSA agriculture means that these targets should be indicative only. Reasonable targets will vary by country, region, and commodity. While quantification of targets may be useful in forming general guidelines and illustrating concepts important to SAATS development and activities, reliance on any single target or number should be shunned.

2.2. Subgoal and target

2.2.1. Subgoal

The subgoal of the SAATS project is increased contribution of the agricultural sector to sustained economic growth.

This subgoal is one of two subgoals of AFR/SD for the ANR sector (the other being broad-based improvements in food security). The empirical underpinnings of this subgoal are found in two empirical observations. First, most Africans and most of the poorest Africans are employed in agriculture, and second, that there is a positive relationship between growth in the agricultural sector and growth in the nonagricultural sector.

Almost 1/2 of the population of SSA lives in absolute poverty (Pinstrip-Andersen and Pandya-Lorch). Most of the poor live in rural areas, often on fragile lands, and are employed in agriculture. For example, 67 percent of the labor force is employed in agriculture and only 9 percent in manufacturing (ASARECA, p. 11). The poorest of the poor often have insufficient land to meet their subsistence requirements (Leonard; Weber et al.).

The positive relationship between growth in the agricultural sector and overall economic growth is quantified empirically in Timmer, e.g.,, who finds that a one percentage point increase in the agricultural growth rate leads to an increase in the nonagricultural growth rate of 0.93 percentage points. In examining this relationship, Timmer finds that

> Several mechanisms can cause growth in agriculture to contribute directly to higher living standards for rural people while also stimulating growth in productivity for the entire economy... In combination, these mechanisms should translate faster agricultural growth into measurably faster economic growth in aggregate, after controlling for the direct contribution of the agricultural sector to growth in [gross domestic product] GDP itself (p. 22).

The potential contribution of agricultural to overall economic growth leads Timmer to conclude that the agricultural sector is the desired starting point for the development process.

2.2.2. Target

For SSA as a whole, the agricultural sector contributes 27 percent of gross domestic product

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(GDP). Along with Timmer's quantification of the relationship between agricultural and nonagricultural growth, this figure provides the information necessary for determination of the target rate of growth of agricultural GDP: 3 1/4 percent per annum (p.a.). This rate of agricultural growth and the complementarily between agricultural and nonagricultural growth means that the economy as a whole is expected to grow at 4 percent p.a.[1,2]

Many of the poorest countries will gain more than 25 percent of their GDP from agricultural—for these countries, the figure will be in the neighborhood of 50 percent. As the agricultural sector is larger in these countries, so also must be its contribution to overall growth. If agriculture provides 1/2 of GDP, then the growth-rate target rises from 3 1/4 percent to 3 1/2 percent p.a.

2.2.3. Further issues

The importance of using agriculture to stimulate sustainable economic growth is summarized by Pinstripe-Andersen and Pandya-Lorch.

> Agricultural intensification addresses the root causes of poverty in many low-income developing countries: agriculture is the most viable lead sector for generating incomes and employment in both farm and nonfarm economies in most developing countries. ...agricultural intensification holds great promise as an instrument to simultaneously alleviate poverty, meet food needs, and avoid exploitation of the natural resources (p. 1).

It is clear that to contribute to the goal of broad-based economic growth, agriculture must not only grow at a sufficient rate, but must also contribute to growth in the nonagricultural sectors in a way that does not denigrate the natural resource base.

Consequently, it is crucial to delineate not just the 3 1/4 percent target for agricultural GDP growth, but also the contributions of agriculture to the 4 1/4 percent growth target for the nonagricultural sector.

The process through which agriculture contributes to overall economic growth is known as agricultural transformation or structural transformation.[3] Staatz describes the process of structural transformation as involving the long-run transfer of resources to the nonagricultural economy; greater reliance on markets rather than subsistence farming, due to specialization and exchange; and "increased access of individuals to knowledge systems of [the] wider world, as embodied in new technologies, management practices, and institutions (p. 4)." While in the long run there will be a voluntary transfer of human resources to nonagricultural production activities, in the short run, reliance on specialization, exchange, and new techniques and practices is facilitated by appropriate investment in the agricultural sector. Staatz goes on to argue that "the major policy issue is ...how to use investment in agriculture and the rest of the food system as a tool for transforming the structure of the economy, thereby increasing overall productivity and broad-based growth (p. 1)." Mellor argues that for

countries whose economies are predominantly rural, "an agriculture-based growth strategy provides the only possibility of broad-based participation by the poor (p. 127)."

The SAATS strategy for agriculture-led transformation gives three roles to the food system: to help people feed themselves, to stimulate nonagricultural growth, and to develop new products and services. People are better able to feed themselves if they are able to produce more for their own consumption, or if they able to generate additional income to have more flexibility in purchasing food. Four contributions from agriculture stimulate nonagricultural growth: release of agricultural labor to nonagricultural production, food production for the nonagricultural labor force, foreign exchange generation, and purchase of nonagricultural goods by rural residents via market transactions (Johnston and Mellor, Staatz). The development of new products and services can contribute to income and foreign exchange generation, and to enhanced exchange of agricultural and nonagricultural goods.

The role of the food system in helping people to feed themselves is inextricably linked to broad-based improvements in food security, which is a subgoal of the SD Agriculture and Natural Resources Sector goal (but not of SAATS because it is not in SAATS manageable interest—SAATS is not relief oriented and hence cannot respond to all of the short-term crises that impact food security). SAATS does contribute to an agricultural transformation that promotes this SD subgoal. This contribution is elaborated upon in the section 2.2.3.

The two fundamental characteristic of agricultural transformation most crucial to investment in sustainable technology systems are embodied in the release of labor to nonagriculture and the production of food for the labor force. First, it is impossible to increase food production and release labor without increasing labor productivity; it is nearly impossible to increase agricultural labor productivity without also increasing land productivity (yields). Second, production of food for the nonagricultural labor force means production, processing, transport etc. via a distribution systems that makes adequate quantities and qualities available at affordable prices. This requires productivity improvement in both the on-farm and off-farm components of the food system.

2.3. SAATS problem statement and strategic objective

2.3.1. Problem statement

Increased production of food for the nonagricultural sector requires productivity improvement in both the on-farm and off-farm components of the food system. Improved productivity at the farm level is meaningless to the consumer if the food is not shipped to the consumer and if the increased farm-level productivity is not reflected in lower food prices. A necessary condition for agricultural transformation is increased productivity of the off-farm portion of the agricultural sector (processing, shipping, wholesaling and retailing, and preparation).

The problem with past TDT activities is that they have neglected off-farm production.

Past activities have been relatively ineffective in alleviating off-farm constraints to and encouraging off-farm opportunities for agricultural transformation. Considerable time and money has been devoted to improving on-farm productivity, with some notable successes (Oehmke and Crawford, Oehmke, Plucknett). While isolated efforts and successes have been achieved in improving off-farm productions, the overall neglect of this area has meant that conditions sufficient for agricultural transformation, most notably a greater ability in the economy to rely on markets rather than subsistence farming, have failed to be met.

Three subsidiary issues arise due to the neglect of off-farm TDT activities. (1) There is a lack of understanding of the socioeconomics of production-to-consumption activities in most commodity subsectors for most SSA countries, including lack of knowledge of which intermediate products are most amenable to improvement TDT and hence are high-priority targets. (2) There is a lack of knowledge about the impact of agricultural policy on off-farm production. (3) There is a lack of information about available and adaptable techniques and techniques that are able to be developed that may improve the high-priority products.

2.3.2. Strategic objective

The strategic objective of the SAATS Initiative is increased and sustained productivity of priority agricultural-and-natural-resource system products.

There are five critical concepts in this strategic objective.

Increased Productivity means that technical progress is utilized to generate greater output from existing levels of input. High-yielding varieties are typical on-farm technical improvements; packaging that retards shipping damage and spoilage is a typical off-farm improvement.

Sustained means that the technical progress and the TDT process generating and diffusing this progress does not degrade the natural resource base, preserves adequate political support for the technology system by empowering users groups and other agents in the ANR system, and maintains the financial Sustainability of the technology system so that continued progress and technical change is possible.

ANR System means the set of resources, institutions, policies, actors and actions that transform unimproved resources into food eaten by consumers. It extends from agricultural production to consumption. This system includes all off-farm production activities of the ANR sector, including small and large agribusiness and food and fiber businesses. Explicit recognition of these off-farm components of the system allows redress of the past neglect that constrained agricultural transformation.

Priority Products mean those on- and off-farm raw, intermediate and consumer products that have the greatest potential for contribution to agricultural transformation. It also means that not every intermediate product in the cotton-to-shirt or maize-seed-to-ugali continuum is a

priority. In some cases, such as French beans in Kenya, the specific constraint to improved export performance may be lack of quality control on the shipped product. In other cases, lack of appropriate varieties, agricultural chemicals or other agricultural inputs may be the constraint. In still other cases, such as with small grains, the development of a blended flour amenable to consumer preferences may be an opportunity to stimulate transformation, and the constraint, research target may be development of a new consumer product.

2.3.3. Further issues relating productivity to agricultural transformation

Increases in agricultural productivity (particularly labor productivity) facilitate the release of labor from agricultural to the nonagricultural sector. An innovative component of the SAATS strategy is to generate productivity-increasing techniques that result directly in improved manufacturing and service-sector performance. These techniques include those outcomes of off-farm research that increase productivity and profits or employment of postharvest, agribusiness manufacturing and service firms. Illustrative examples of such outcomes might include improved milling techniques, better packaging that reduces transport loss, lengthening shelf-life of processed meals in retail outlets, the development of new products such as nontraditional exports, etc. It is this characteristic of development that leads to two of the desired characteristics of TDT: that TDT be demand driven and that it follow a commodity-sector approach (Strategic Framework).

Within the agricultural sector, increased productivity leads to increased food availability and lower prices for food and other agricultural goods. Food availability at affordable prices provides a general stimulus to nonagricultural business.

Lower food prices directly increase the real wage rates of wide segment of the poor population. It is widely acknowledged that the real wages of nonagricultural laborers rise as food prices decline. What is less widely known is that a significant proportion of African smallholders are net purchasers of food staples, so that a decline in the price of these staples also increases the real incomes of these smallholder farmers (Weber et al.). Thus, Mellor's argument that "change in relative food prices is, in the short run, one of the most important determinants of change in the relative and absolute real income of low-income people (Mellor, p. 168)" in many cases applies to the rural poor as well as the urban poor. Explicit consideration of 'Weber-households' (smallholder, net purchasers) and the desire for broad-based transformation will lead to decreasing food prices as an outcome-target for the SAATS activity.

A positive result of the lower food prices caused by productivity increases is an improvement in food security. The poorest of the poor are often rural, smallholding consumers who are unable to grow enough to feed themselves, and consequently must purchase foodstuffs in the market or through in-kind payments for their labor. By increasing labor productivity and by lowering the cost of food, SAATS will improve the food security and welfare of this target population.

Increased savings from poor, urban and Weber households and from corporate reinvestment in profits will lead to capital accumulation and investment in nonagricultural production and processing techniques.

A second, innovative aspect of the SAATS paradigm is the fostering of links among capital accumulation and agricultural and nonagricultural technology. Capital accumulation, especially by Weber households, could consist of livestock or agroforestry purchases or investments in land sustainability. Such investments will be facilitated if improved-quality capital goods (e.g., better livestock breeds, tree and shrub varieties or NRM techniques) are available from the TDT system. Improvements in nonagricultural techniques may be complementary to improvements in agricultural techniques, for example development of a plant with medicinal characteristics may lead to innovation in pharmaceutical processing. Conversely, improvements in cold-storage techniques may lead to greater demand for nontraditional exports such as fruits, vegetables or cut flowers, which may increase the benefits of agricultural TDT directed at on-farm production of these products.

Finally, the bottom line is the well established linkage between capital accumulation, technical change, and economic growth.

2.3.4. Targeting and achieving agricultural productivity growth

Targeting Agricultural Productivity Growth. The pertinent question is: what sort of productivity growth targets are compatible with growth in agricultural GDP of 3 1/4 to 3 1/2 percent p.a.?

An agricultural-sector growth rate of 3 1/4 percent can be achieved through obtaining better prices, greater input use, innovation, or other means. With much of the high-potential land in Africa already under cultivation, and NRM considerations coming to the foreground, it is unlikely that much future growth can be sustained through extensification. Labor inputs can perhaps increase by 2 percent per annum; with population growth rates close to 3 percent this allows a annual reallocation of 1 percent of the agricultural labor force to nonagricultural activities. If the agricultural sector is to offer cheaper food, then food prices must decline. Specific evidence on the rate of food-price decreases necessary to stimulate nonagricultural growth is not available; 1/2 percent is set as a target as this will generate a cumulative decline of about 14 percent in thirty years. Under this scenario, increases in capital and purchased inputs and multifactor productivity must generate increases in agricultural GDP of 2 3/4 percent per annum.

If inputs of purchased inputs such as fertilizer can grow at the rate of 5 1/2 percent per annum, then productivity needs to increase at 2 percent per annum (at base-period prices) to achieve an agricultural-sector growth rate of 3 1/4 percent. The target of 2 percent per annum increase in agricultural productivity is the primary target for biophysical TDT.

Achieving 2 percent Annual Productivity Growth. Achieving annual rates of agricultural

productivity growth of 2 percent per year is a difficult task. By way of comparison, one of the notable successes in world agriculture is the U.S. maize sector:

> "[In] 1931, the U.S. yield of maize was 1,500 kg/ha, a normal crop. In 1978 this yield came to 6,300 kg/ha. Although the maize area harvested in 1978 was 16 million hectares less than in 1931, total production was over 175 million metric tons, compared with 65 million tons in 1931 (Schultz, p. 373).

This works out to an increase in yields of about 3 percent per annum; accounting for increased use of capital and purchased inputs gives a smaller overall productivity increase. At an aggregate level, U.S. agricultural multifactor productivity increased at an annual rate of about 1.5 percent over the period from 1889 to 1991 (Huffman and Evenson). Over the next few decades, African agriculture will be asked to better this record.

There is substantial hope that this lofty objective can be realized, particular if the technology system is focussed on key constraints and opportunities. The advantage that Africa has is the opportunity to rely on past experiences of developed countries and prior research results. Instead of carrying out the array of R&D activities that the U.S. went through to develop hybrid maize, SSA needs to emphasize the copy and apply (C&A) paradigm: copy those adaptive research processes which have been successful in the past, and apply known research results and improved agricultural techniques to obtain significant gains in productivity with relatively little effort. An example successful C&A is the Chilean maize subsector, which boasts the highest yields in the world. Africa needs similar endeavors.

Both the biophysical and social sciences have critical roles to play in achieving a 2 percent rate of productivity growth. The biophysical sciences will concentrate on the development of techniques that deliver larger quantities, higher qualities, or higher-valued agricultural and food-system products to the consumer. The social sciences will work with the biophysical sciences to help identify which qualities and products are likely to generate the highest increase in value to society.

To achieve this productivity target requires efforts both on-farm and off-farm. For example, in Zimbabwe 2/3 of the retail value of maize meal arises from postharvest activities, 1/3 is generated on the farm (Takavarasha and Jayne). While farm-level

Box 2. Chile's Success with Maize C&A.
The Chilean government and technology system participants wanted to improve maize yields, but did not have the financial capacity to undertake an extensive breeding program. Instead, the decided to obtain hybrid materials suited to those regions in the U.S. which were most comparable agro-ecologically to potential maize regions in Chile. Screening and testing was done to select the best varieties; these varieties were then transferred to farmers. Chilean maize yields are now the highest in the world--without a single new varietal release.

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innovations will continue to provide the greatest potential for broad-based welfare gains, important benefits can also be generated by looking at the off-farm components of the commodity sector.

2.3.5. Targets for SAATS interventions

It is beyond the scope and manageable interest of the SAATS Initiative to generate productivity increases of 2 percent and the other necessary contributions to agricultural transformation throughout entire ANR sectors in SSA. The SAATS activity will focus and concentrate on those priority commodities which have the highest potential for rapid increases in productivity and where such increases can make substantial contributions to agricultural productivity. Consequently, it is necessary to know how the 2 percent productivity growth target is to implemented for these priority commodities.

The targets of interest are multifactor productivity, reduction in per-unit costs of production, land and labor productivity, output increases, foreign exchange generation, and resource sustainability measures.

Multifactor Productivity. Multifactor productivity (MFP) measures the amount of output generated per unit of input. The adjective multifactor arises because this measure attempts to quantify all measurable factors used in the production process (this measure is also known as total-factor productivity; due to the inevitable omission of some factors the adjective multifactor is used herein). Multiple outputs and inputs are usually aggregated into output and input numbers, respectively, using fixed output and input prices. In this case there is a direct relationship between MFP and per unit costs of production.

MFP is the measure most directly linked with the concept of productivity increases discussed above. An indicative target for MFP growth is an increase of 2 percent p.a. (derivation of this and other targets is contained in Annex 1).

Per Unit Costs. Reductions in per unit costs translate into more affordable food and more competitive exports, improving food security and providing foreign exchange. Reductions in per unit costs can occur anywhere in the food system: reducing transport, processing or packaging costs may be equally important as reducing on-farm production costs. Cost reductions can be achieved through increasing the productivity of some or all inputs or intermediate products, capturing economies of scale, or improving the processes through which agricultural products move en route to the final consumers.

Per unit costs can be calculated using either fixed prices or varying real prices. Use of fixed prices gives a strong indication of the direct effect of technical progress. Using varying prices more accurately reflects changing socioeconomic conditions, and provides a better indication of whether costs to consumers are rising or falling. The latter measure is particularly useful when the priority product is an intermediate output such as cloth for shirt manufacturing or grain meals and flours for use in baking. The latter measure also provides more information

about how the subsector is responding to changes in the policy and market environments.

A minimum target for decreases in per unit costs of priority products, measured using varying real prices, is 1/2 percent per annum.

This is a minimum target because a 1/2 percent decrease at a single step in the production-to-consumption continuum does not guarantee that consumer prices will decrease by 1/2 percent. An alternative target is a 1/2 percent p.a. decrease in the per unit cost of all consumption goods whose manufacture requires use of the priority product or a derivative; however, this may require a substantially larger decrease in the per unit cost of the priority product if it contributes a small fraction of the cost of the consumer good. For example, if maize grain constitutes 25 percent of the cost of ugali, then it will take a 2 percent decrease in the per unit cost of producing maize grain to allow a 1/2 percent decrease in the cost of ugali (with no other changes).

Land Productivity. The target of land productivity (yield) is the most commonly used measure of the impact of TDT on production. Increases in yields due to modern varieties, fertilizer use, and investments in land an rural infrastructure were the driving force behind the Green Revolution in Latin America and Asia. Yield goals are directly translatable into TDT outcome targets. For example, a target of tripling maize yields from 1 1/2 t/ha to 4 1/2 t/ha could be achieved by a combination of varietal improvement, improved crop and land-use management, and increased fertilizer input. The particular contribution of each of these items to the overall target will depend on the local and regional agroecological and economic conditions.

Increases in land productivity can help to stimulate sustainable transformation in two ways. First, increases in yields are a crucial component of increasing overall production, which in turn makes food available to domestic consumers and increases the availability of exportable goods for trade. Second, yield increases stemming from intensification on high-potential lands mitigate extensification onto fragile lands. Area expansion onto fragile lands unsuitable for cropping or intensive grazing is perhaps the most frequent cause of land degradation in Africa; increasing yields on less-fragile lands can provide a profitable alternative to farmers considering area expansion.

Land productivity is generally applicable at the farm level, and generally inapplicable in activities such as processing, packaging and transport.

A indicative target for annual rates of increase in land productivity is 4 percent p.a. This target is compatible with the strategic objective target of 4 percent p.a. growth in physical output with no increase in land use. However, it is not strictly a necessary condition, as higher-than-targeted growth in other partial productivity measures could offset a lower-than-targeted outcome for land productivity. Extensification could also offset a lower-than-targeted outcome.

Labor Productivity. Improved labor productivity also translates directly into a criterion against

which potential TDT activities can be judged. Labor productivity is measured by the quantity or value of output per unit of labor used. It is important to specify the output(s) correctly—all affected outputs are to be included. For example, some improved cereal varieties may have high grain output but lower fodder output than traditional varieties; some legume varieties may have high output but poor nitrogen-fixing capacity. It is important to consider both quality and quantity: improvements in output quality that augment value are legitimate targets for TDT activities. For example, Indonesian oil-palm processors earn a premium if the ? content is lowered from 5 percent to 2 percent; apparently African producers have not yet taken advantage of this quality improvement. It is important to measure labor accurately to generate an accurate measure of labor productivity. For example, output per capita is a measure very different from output per person-year of labor.

Increases in labor productivity (output per worker) are key to improving agricultural wages (whether market or implicit). Particularly in rural areas with high population density, poor smallholders may depend on wage employment for a substantial share of their incomes. Increases in agricultural wages allow these smallholders to benefit from transformation.

Labor productivity is applicable in each portion of the commodity sector. For example, TDT that discovers on-farm methods for reducing bulky raw products into easily transportable intermediate products will increase the labor productivity of the farmer or entrepreneur who takes these products from the farm to the market (and beyond).

The target for labor productivity is an increase at the rate of 2 percent p.a. This is compatible with the overall target of 3 3/4 percent growth in agricultural output, but is not a necessary condition as above-targeted performance in other areas could compensate for below-targeted performance in labor productivity.

Output increases. Despite the fact that the analysis has broken out the contribution of various components to increases in output, this aggregate measure remains a useful indicator. Mellor argues that there is a direct link between increase in agricultural output that exceed the population growth rate, and increases in per capita income.

The target for increases in physical output is 3 3/4 percent p.a.

Export Earnings. Generation of scarce foreign exchange through export earnings has several advantages, among them more flexibility with macroeconomic policy, easier access to imported inputs, and greater availability of foreign capital and improved techniques developed abroad. The crux of the matter is that "foreign exchange earnings (or savings) can also produce large benefits in terms of income streams and employment (Schuh, pp. 196-7; parenthesis in original).

Specific targets for export earnings are dependent on the national and regional economies and the commodity under consideration. It does little good to specify a foreign-exchange target for a nontraded commodity. For traded commodities, the foreign-exchange-earnings target will be

related to comparative advantage. For example, Kenya imports wheat, and by increasing wheat production could generate foreign-exchange savings. Yet most of the imported wheat is PL480 aid, which has little foreign-exchange cost, and much of the potential wheat area would replace coffee area or tourism activities (Makanda), possible resulting in an overall decrease in foreign-exchange available to the economy. Consequently, targets must be set on a case-by-case basis.

Resource Sustainability Measures. Sustained increases in productivity are possible only if the natural resource base is maintained or if substitutes for these resources are available. While there are at this point no canonical measures of resource sustainability, several promising avenues of investigation are emerging. These areas are detailed in the report of one of the technical specialists (Mark Powell).

2.4. Program outcomes and targets

2.4.1. Program outcome 1 and targets

The first program outcome is increased use of sustainable and profitable techniques.

There are three direct and causal links between this program outcome and the strategic objective of increased and sustained productivity.

The first link is that sustainable and profitable techniques are a direct cause of increased productivity. This statement is true regardless of whether the techniques are applicable on-farm or at later stages of the food system.

The second link is through improving the options available to the farmer with respect to production and natural resource management. Increased use of profitable techniques provide the farmer with a little bit of extra output or income that s/he can use to buy additional inputs, to improve implements, to purchase livestock, or to invest in land improvements. Each of these investments in turn generates further increases in productivity, arrests natural resource degradation, or improves the sustainability of the farmland. Moreover, as improved techniques increase land productivity, the value of farmland will increase and farmers will have more incentive and flexibility to make the investments necessary to sustain the value of this natural resource.

Box 3. The Complementarily Between NRM and Productivity in Upland Rice.

Upland rice is produced on 2,047,000 ha or 50 percent of the rice lands of Africa and thus is the most common form of rice production. Most of this rice is produced as the pioneer crop in slash-and-burn, shifting, agricultural systems, with yields of approximately 1 t/ha. Slash and burn is normally considered environmentally unstable, and in most soils a second crop of rice will be overwhelmed by weeds and abandon prior to harvest. However, complementary NRM and productivity research shows that under extremely favorable soil conditions upland rice can be reasonably productive and obtain sustainable yields exceeding 4 t/ha each year (the current yield plateau for irrigated rice). These soils are friable, highly permeable soils that allow for rapid, nonerosive infiltration of rainfall, and mechanical working of the soil independent of rainfall. They are either young soils derived from volcanic ash or old, highly weathered, dark red soils. Both soil types are usually physically stable and thus do not erode even on fairly steep or rolling terrain. Working within NRM constraints on such soils, productivity-targeting TDT can focus on phosphorus application and management and improved weed control.

SOURCE: Tinsley

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The third link is through the replacement of extensification with intensification. Further extensification in SSA is likely to take place on fragile or erodible soils. Such extensification poses a much greater risk of resource degradation than does intensification of relatively strong soils. While caution must be exercised in finding techniques that allow intensification on fertile soils without contributing to resource degradation, the ability to increase the use of such techniques is of paramount importance in sustaining increases in productivity.

Targets for this program outcome should reflect the diversity of African agriculture, the long-term nature of research and development (a minimum of ten years), and the short-term life of SAATS as a USAID project (right now scheduled for five years). Even by targeting high-priority commodities, it is unlikely that SAATS will be able to influence the commodity subsectors that generate more than 1/3 of agricultural GDP. However, this makes a first target: that SAATS generate, disseminate, or transfer improved techniques in subsectors that cover at least 1/3 of ag GDP in each region.

Indicators of progress towards this outcome for individual techniques include number of adopters, the projected adoption ceiling or size of the target population for the particular technique (development of techniques serving a broader population are more likely to stimulate transformation), the proportion of the target population currently adopting, the intensity of adoption (e.g., fertilizer application rate or fraction of improved breed in total herd), the ceiling level of intensity, and the proportion of current-use intensity in the ceiling level (e.g., the current fertilizer application rate in SSA of about 9 kg/ha is probably 10 percent of what could be applied sustainably and profitably, given the right enabling conditions).

SAATS will endeavor to bring multiple new techniques into use. An important criterion of impact on use and aoption is the number of producers (or consumers) who use at least one new technique (or product) on a regular basis. Users of multiple improvements (e.g., improved breeds and veterinary services) are likely to be well on their way towards increased productivity, if they have not already achieved substantial increases. Thus, a second important indicator for monitoring progress is the number of multiple-technique users, and the average number of improved techniques per adopter. Adoption ceilings and the proportion of the ceiling level currently adopting are also important indicators.

A concurrent target is the potential impact that these improved techniques have. These techniques should lead to a cost reduction of at least 10 percent per year for three years, among adopters (or 30 percent for a single year). The three-year nature of this target reflects differences in the intensity of adoption. For example, a farmer may plant an improved variety on 1/3 of her land in the first year she tries the variety, as a test. If successful, she may increase the amount of land planted to this variety as well as the level of inputs applied, leading to successive reductions in the per unit cost of production.

Alternatively, targets such as land productivity (2 percent increase for each of three years), labor productivity, multifactor-productivity, or export earnings could be used instead of per

unit cost reductions, depending on how the specific innovation is intended to further the strategic objective.

The improved techniques should also meet targets for sustainability. These targets are discussed in one of the technical specialist's reports (Mark Powell).

Targets for adoption are also important. Adoption and use of improved techniques usually follows an S-shaped (ogive) pattern with respect to time. In early years, only a few percent of the potential adopters will use the innovation. As time passes, adoption becomes more and more rapid, until most people are using the innovation and the number remaining to adopt dwindles. Consequently it is important to set targets both for the potential number of adopters and for the annual adoption percentages. A fixed target of the potential number of adopters is inappropriate due to the diversity of African agriculture and the diversity of possible innovations; however, the potential number of adopters should be consistent with the GDP-target calculation. For example, suppose the maize subsector contributes 1/3 of agricultural GDP, and a short-cycle, drought-resistant variety is introduced. This variety may be profitable only among smallholders on marginal lands, who contribute say 1/2 of maize production. Then this varietal innovation would cover 1/6 of agricultural GDP, not 1/3, and so additional innovations would be necessary to hit the 1/3 target. Then, adoption among the smallholder must start. One possible target is that within three years after release, 8 percent of the potential adopters are using the innovation. Based on previous experiences with adoption curves (e.g., Henry de Frahan, Boughton), this is sufficient to hold the possibility of significant and rapid adoption by the majority of the target population in the succeeding five years.

2.4.2. Program outcome 2 and targets

The second program outcome is increased availability of and access to profitable and sustainable technology.

SAATS will achieve this outcome by assisting regional and national TDT systems in making currently used techniques more accessible, by introducing known but unused techniques into the mix, and by developing additional improved techniques. As part of the empowerment of Africans, the specific techniques to be investigated should be determined by the African organizations. Consequently, indicators and criteria will be somewhat unspecific at this stage of the SAATS Initiative.

It is expected that at the end of the project there will be a greater number of techniques to select from in priority areas. These techniques may be improved methods for growing or processing agricultural outputs, or they may be embodied in improved-quality inputs or outputs. Currently known techniques will be available from a wider variety of sources, providing greater geographic and demographic coverage of the market; techniques currently in use will be made available at lower real prices. The availability will be commensurate with covering commodity subsectors contributing 1/3 of agricultural GDP, as discussed above.

Specific indicators for monitoring progress will depend on the priority areas chosen. General principles to be followed are that the criteria include the number of techniques among which demanders can choose; the ease of adoption of these techniques; and the pecuniary and nonpecuniary costs of obtaining the inputs necessary to adopt the technique. For example, maize breeders may develop six short-cycle varieties suitable for drier, marginal areas; these varieties may be easy to adopt in that they do not require changes in the traditional planting or harvesting routines; but if the varieties are available only in the large cities then access is limited. Similarly, improved consumer products are only as accessible as the nearest store or retail outlet carrying such products.

Some general guidelines can be thought about. Each of the innovative techniques or products developed and disseminated should be available in stores, retail markets, or other outlets visited at least once a year by 80 percent of the target population (potential adopters). The real price of improvements embodied in purchased inputs, such as hybrid seeds, shall have declined (measured as same-store sales).

In addition, SAATS must look continually to generate additional innovations for dissemination after the life of the project. At the end of the project, potential innovations covering another 1/3 of agricultural GDP should be in the screening and testing stage, with projected dates of release within five years of the end-of-project.

2.4.3. Program outcome 3 and targets

The third program outcome is strengthened human and institutional capacity for ANR technology systems.

The initial focus of the strengthening activities is on the empowerment of Africans in harmonized, regional, TDT priority setting. Indicators that this has happened include: (1) an established regional TDT body with predominantly African membership, (2) established criteria/voting rules in the body for selection of TDT priorities, and (3) allocation of funds based on the selected priorities. The first two indicators are yes/no and the target is an affirmative answer. The third indicator could be measured as the percentage of available funds allocated via the priority setting mechanism. Allocation of 75 percent of the funds to selected priorities after five years is sufficient to move the TDT agenda forward, yet allows flexibility to invest in secretariats, special activities, and other areas necessary for the smooth functioning of the regional body.

The key achievements to be made here are legal incorporation; certification to receive funds; adequate representation of national interests in the organization; adequate representation of private sector interests in the organization; endorsement by the organization of guidelines for information to be used in cross-commodity and within-commodity priority setting for technical and programmatic activities, based on economic, social and technical analysis; endorsement of protocols for actually making the priority-setting decisions; protocols for determining which regional training, technical assistance, and other activities for strengthening

national institutions are to be supported, and to what extent; implementation of monitoring and evaluation procedures, implementation of accounting procedures for financial management, and implementation of procedures supporting eventual impact assessment.

2.4.4. Program outcome 4 and targets

The fourth program outcome is policy and market environments allowing for agricultural transformation in priority subsectors.

In defining this program outcome, considerable care was taken in choosing the phrase 'policy and market' to reflect both public-sector (policy) and private-sector (market) attitudes and actions that could influence the development, dissemination, or use of improved techniques. The composite of these attitudes and actions, the policy and market environment, will be harmonized, to the extent possible, with the efficient operating of the technology systems. This is not to say that subsidies or other financial support for technology external to the TDT system is needed: there is considerable doubt that subsidies are economically efficient (e.g., Howard for pricing subsidies in Zambia; Meyer on credit for agricultural inputs). The environment needs only 'allow' for transformation by establishing a well-articulated set of ground rules that are reasonably neutral with respect to agricultural. A good example is the establishment of protection for intellectual property rights. The lack of rules for IPR protection prevents multinational companies from introducing their improved germplasm in African countries. The fear is that they will invest in physical plant, contacts, and personnel in a country, but that their varieties will be copied and they will not be able to recoup the cost of their investments. Stakeholders in Kenya cited this as a major reason why they could not get the best varieties for their horticultural crops. The result is lower yields and lower-quality fruits and vegetables. To remedy this, well-specified IPR protection is needed: this allows for introduction of improved varieties, but provides no subsidies or other incentives to introduce them other than what is available in the marketplace.

2.5. Program activities

2.5.1. Activities common to East and West Africa.

SAATS will engage in four innovative activities, to enable technology systems more strongly to stimulate agricultural transformation. The implementation of these activities will differ somewhat by region. However, their central thrusts are common, and the innovative nature of these activities requires them to be brought to the foreground of the SAATS Initiative. These activities are: establishing and sustaining a regional organization for harmonization of national and regional technology-systems activities; establishment of a social-science and policy research activity; establishment, consolidation, and rationalization of an input distribution activity tailored to enhancing the use of profitable and sustainable techniques; and establishment of a food technology activity.

2.5.1.1. Institutionalizing regional organizations

It is impossible to harmonize national and regional technology-systems activities without a coordinating mechanism. The proposed regional organization will serve as this coordinating mechanism.

In East Africa, ASARECA holds the greatest potential for providing coordination. ASARECA as yet does not formally exist; its current essence is only as a memorandum of understanding signed by the NARI directors in East Africa. Under World Bank sponsorship, ASARECA has established a working secretary and is seeking incorporation for the secretariat under Uganda law. At the same time, the NARI directors are striving for endorsement by the Ministers of Agriculture from their respective countries.

One of many possible agendas for building the ASARECA institutions is presented in ?. In the initial years, greatest concern is for the establishment and development of the institution. In some cases, this includes establishing working groups or other units to address areas of opportunity previously neglected (e.g., social science and policy). It is expected that these units will go on with a complementary agenda to achieve impact, and so outcomes from these

Table 1. Illustrative Agenda for Institutionalizing Asareca.

DATE	ACTIVITY OUTCOME
FY 95	
April, '95	Legal Incorporation
July, '95	Criteria for Commodity Selection in Place
	Criteria for Constraint/Opportunity Selection in Place
	Economic Information for Commodity Selection Available
	Draft Monitoring and Evaluation Guidelines in Place (Quarterly, Annual, Midterm, Final)
	Social-Science Research Activity in Place
	Food-Technology Activity in Place
	Input-Distribution Activity in Place
FY 96	
Oct., '95	Determination of Priority Commodities
Jan., '96	Sub-sector Analyses Complete for Priority Commodities
April, '96	Draft TOR for Working Groups on Priority Commodities: Includes Mechanism for Addressing Private-Sector Demands.
July, '96	Working Groups in Place for Priority Commodities.
July, '96	Monitoring and Evaluation Guidelines Approved
July, '96	Draft Impact Assessment Guidelines
FY 97	
Oct., '96	Allocation of Funds in Accordance with Priority Commodities and Constraints/Opportunities
	Working Group Recommendations on ASARECA Protocol on Transfer of Borrowed Techniques
Oct., '96	Impact Assessment Guidelines Approved Certification of ASARECA to Receive and Manage Donor Funds.
Jan., '97	Protocols for Borrowing and Transfer Formalized and Endorsed
	Midterm Monitoring and Evaluation Report Available, Including Impact and Progress Toward Impact
April, '97	Revisit Criteria for Commodity and Constraint/Opportunity Selection--Necessary Changes Made.
July, '97	
July, '97	
FY 98	
Oct., '97	Revisit Priority Selection for Commodities and Constraints
Oct., '97	Continuing Allocation of Funds per Revisited Priorities
Oct., '97	Working Groups Addressing 2d Generation Problems, Constraints and Opportunities
Jan., '98	Mechanism for Purchase of Techniques To Be Borrowed
April, '98	Revisit Institutional Arrangement for Empowerment of Private-Sector Technology Users
July, '98	Draft Protocol for Sustainable Funding Mechanism
FY 99	
Oct., '98	Adjustment Made to Empowerment Arrangements, Priority-Setting Guidelines
	Priorities Revisited
Oct., '98	Continuing Allocation of Funds per Revisited Priorities
Oct., '98	Sustainable Funding Mechanism in Place and Receiving Funds
July, '99	Institutional Innovation as Needed to Maintain Focus on New Constraints and Opportunities, and
Sept., '99	Appropriate Responses
Sept., '99	End-of-period output and impact analysis.

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activities do not appear: it is the institutionalization of such activities that is of central concern to the current discussion.

In West and Central Africa, there is no NARI Director's Committee or comparable umbrella organization. Consequently, the agenda for West and Central Africa is to come to agreement upon what such an organization might look like, and then to institutionalize this vision. The particular nature of institution-building activities might vary from those in East Africa, depending on the nature of the West/Central African organization. However, the template of East African institution-building activities could serve as one alternative for West/Central Africa, with an implementation delay of 1–3 years in order to start up the regional umbrella organization.

2.5.1.2. Social science and policy activity

The impact that technology systems can have in catalyzing agricultural transformation is largely dependant on the socioeconomic environment ambient to these systems. In many cases, the technology system itself may be able to improve the environment; in other case the technology system may have to take the environment as given, but can make decisions about how best to stimulate transformation given the socioeconomic conditions. These two options form the basis for the social science/policy activity.

The initial social-science activity should be to facilitate the development of the regional organization, particularly through assisting with priority-setting, and establishing monitoring and evaluation and impact assessment capability. This will require establishing a social-science working group, unit, or similar capacity at the regional level. Such unit could initially contain a single individual, and be housed at the regional secretariat. Responsibilities would be (1) to respond to priority-setting needs at the regional level, (2) to facilitate development of socioeconomic units within the NARS, including social science sensitization workshops, training workshops, and a small amount of technical assistance, and 3) developing plans to respond to further needs of the regional and national organizations with respect to social science activities.

It is expected that regional and national organizations will quickly want to become involved with policy analysis. Improved policies, in complement with extant techniques, may provide an easy way to generate benefits in a relatively short time period. For example, liberalization of transport restrictions may provide incentives to farmers to invest in greater input use, including inputs to preserve natural resources. Specific policies may also directly impact public and private technology systems. For example, improved IPR protection may encourage greater availability and dissemination of improved varieties by the private sector.

The social-science/policy activity should respond to those needs that are national and regional priorities, and that can best be accomplished by a regional organization. For example, coordination of IPRs across countries is by necessity a regional endeavor; analysis of the impacts of different coordinating mechanisms is a legitimate area of social science inquiry.

The activity should be careful not to duplicate or preempt research best carried out elsewhere. One example is regional trade studies: while a single regional study may be far less costly than having each country do their own, the socioeconomic unit envision herein may not be the appropriate unit to carry out such a study. A premier regional university may have comparative and absolute advantage in this area. A second example is the development of a new food product. While the socioeconomic unit may want to provide some impetus to interest the private sector in potential innovations, ultimately the private sector will rely on its own product development and marketing investigations. Thus the socioeconomic unit should provide enough information to entice the private sector, but not so much as to spend scarce resources on investigations that will be repeated by the private sector.

As the demands on the socioeconomic unit grow, the unit will have to expand its core staff. This is particularly true as the unit expands from priority-setting into more general research and policy analysis. For example, SACCAR has moved from a single, regional, socio-economist to two within a period of two years; further expansion is likely.

The particular areas of investigation by the socioeconomics/policy unit will vary by region and by the needs of the NARS. Some examples include:

- Priority-setting. Sensitization, training, and backstopping of priority-setting at the national and regional levels.

- Monitoring and Evaluation and Impact Assessment. Sensitization, training and backstopping.

- NRM and TDT. Provide input on defining the relationship between NRM and TDT; investigation in legal and statutory structures and impacts; implications for TDT and TDT policy.

- Agriculture and Macroeconomy. Emphasis on the relationships between technology and agricultural transformation.

- Price and Marketing. Emphasis on the relationships among market liberalization, price policy, and the adoption and use of improved techniques (on and off farm).

- Food Security, and Drought and Disaster Relief. Defining the role of strategically-oriented technology systems in strategic and tactical responses to such crises.

- Rural Infrastructure Development. Analysis of options for improving the impact of investments in rural infrastructure on rural and smallholder supply response; relationships between access to infrastructure and technical progress.

- Technology Support Institutions. Analysis of options for developing coalitions of farmers, processors, markets and other technology-users' groups to support national and regional activities.

- Rural Enterprise Development. Analysis of options for developing rural enterprise, for increasing the demand for farm products, and for facilitating transformation by providing local source of nonagricultural employment.

- Intellectual Property Rights. Analysis of impacts of different methods for protecting intellectual property; implications for public and private sector investments in TDT.

- International Shared Resources. Analysis of options to reach consensus regarding use of internationally shared bodies of water and other resources; implications for TDT.

2.5.1.3. Food technology activity

There appears to be considerable potential for food technology research on a number of commodities, particularly in the areas of product development. Since food-technology research is an area neglected by traditional activities, specific products and product targets cannot be specified at this time. In addition, the desire for empowerment of Africans suggests that specific activities should be postponed until priorities are set.

However, A.I.D. can anticipate needs and prepare to facilitate response by the regional organizations. Perhaps the best preparation is a compendium of improved post-harvest techniques available in the public and private sectors, with special emphasis on African application, for those commodities with the greatest economic potential. This would serve as a characterization of the "technology frontiers" in the primary 3–5 food crops for each region. The characterization would include not just improved processes for manufacturing existing products, but also new products that could potentially be processed using techniques available in other parts of the world, and introduced into African food systems.

Any such activity would include a market study complementary to the technology frontiers description.

An outstanding issue is whether the food technology activity should be embodied in a stand-alone network or subregional organization. The motivation for doing so would be that in the past, including food-technology activities to be incorporated into the commodity networks has led to a relative neglect of the area. Establishing a distinctive food-technology activity with adequate funding would overcome this problem. However, a stand-alone food-technology activity does not serve to integrate the commodity subsector. There are important complementarities between food and fibre possibilities and the design of on-farm research agendas; such complementarities perhaps are used to their best advantage when food and fibre

technology activities are incorporated into commodity networks. In addition, the complexity of an FFT network grows exponentially as the vertical size of the food and fiber system grows: the (see ?).

2.5.1.4. Natural resources management

A related thematic area is NRM. This is clearly of interest throughout Africa. NRM activities of greatest overlap with SAATS are those directly affecting agricultural technology. These are usually incorporated within a commodity or farming-systems paradigm. Some discussion of how this might be done and indicators for the impact of agriculture on natural resources are contained in one of the technical reports (Powell).

A second perspective on NRM and technology systems is the search for technical solutions to natural-resource degradation problems. This would be a legitimate area of inquiry for the SAATS Initiative. One example of a technical solution is the use of the super-absorbent materials used in diapers as water control technology in reforestation projects.

Very little work, if any, is currently underway on technical solutions to natural-resource degradation in Africa. However, it does not appear as if this avenue of inquiry is likely to yield early results, nor is there a good network or working-group paradigm available at this time. Most of the ongoing work is to classify the areas, types and causes of the most severe degradation; perhaps this classification will be of use in designing or adapting technical solutions.

2.5.2. Activities specific to West Africa

Due to the nonexistence of a unifying regional body for West and Central African agricultural research, the most important activity to be undertaken is the formation of such a body. All other actions are of secondary importance. However, some actions can be taken concurrently with the creation of a regional research organization. As the economist did not travel to West Africa, information provided herein will be somewhat limited. Some additional discussion can be found in the trip and management report of the program management specialist.

2.5.2.1. Training

There is considerable scope for increasing efficiency through short-term, regional training programs. Many of the WCA countries are small and have small research organizations, with only one or two scientists in some specialties. These NARIs cannot afford to be sole providers of training for these individuals. By regionalizing the training program, it would be more cost-effective in presenting knowledge external to the region; at the same time, it would facilitate interaction among scientists within the region.

Priority areas for training are not completely determined. An initial first area would be in commodity subsector studies. Pilot efforts in this area are being carried out under the auspices of IER in Mali; they are working with PRISAS to present the methodology and results at a

forthcoming regional workshop. There is also the possibility of strong collaboration between francophone and anglophone countries here: for example, both USAID and CIRAD are supporting the subsector (filiere) approach in Mali.

2.5.2.2. Scientific information exchange

Scientific advances depend on knowing what has been accomplished already; scientific validation of new results requires reproduceability of those results. Neither is possible without exchange of information among scientists. With the recent advances in computer hardware, bibliographic software, and electronic mail, there is at current no more versatile method of information exchange than via a computer network encompassing all the major actors in national and regional technology systems. The network could make available by electronic means a wide range of notes, articles and books from some central library. Perhaps equally important would be a translation service so that abstracts could be made available in the language of choice. The network would also provide a means for communication of experimental results, new thoughts, and conjectures among scientists within the region.

2.5.2.3. Commodity and thematic areas

In addition, there are some commodity and thematic areas that need attention, such as the livestock subsector, and natural resources management. These areas are discussed in more detail in the program management specialists report.

2.5.3. Activities specific to East Africa

The key thematic areas for East Africa are those common with West and Central Africa: social-science/policy research, post-harvest technology, input distribution, and natural resources management. Key commodity areas, as determined by the stakeholder analysis in East Africa, follow.

2.5.3.1. Livestock

The livestock subsector has the highest value of production of any agricultural subsector in East Africa, and affects large numbers of people. It is also offers great potential for improving the welfare of a large proportion of the farmers and herds-people who live in marginal lands with limited crop potential.

Livestock systems are inherently regional. Participants in nomadic and semi-nomadic systems cross national boundaries at will, and much of the wildlife and livestock system in East Africa fits this pattern, such as the Masai Mara / Serengetti game park system that crosses the Kenya/Tanzania border, the Masai grazing system that crosses the same border, and the herding system stretching from northeast Kenya into Ethiopia and parts of Eritrea and Djibouti. Regional complementarities are also inherent in improvements in livestock and animal husbandry for mixed farming systems, since such improvements have the biological

potential to be easily transferred across political boundaries.

It is unclear why livestock research has suffered from a relative lack of public funding. Possible explanations include a lack of political power among herders, who tend to live away from urban centers of power; appropriability of returns from breed improvements by the private sector; conflicts between farmers and herders; and lumping of livestock as a single commodity (v. the delineation of specific crops) to get a single dollop of funds. Within AID, support for livestock has declined because of a perceived lack of progress, although specific impact studies on livestock research are not available.

Livestock is a priority area for KARI and IAR, based upon its importance to Kenya and Ethiopia. Specific opportunities and targets for improvement are not yet available. The small ruminant CRSP seems to have had some success with the dual-purpose goat in Kenya, although greater dissemination is needed. ILCA has had some success with smallholder dairy systems and is working on developing dairy cattle capable of plowing and tilling with minimal loss in milk production. Progress has been made in vaccine development. ILCA is currently involved in a livestock baseline study with which they hope to characterize the most important problems and the potential impacts of alleviating these problems.

2.5.3.2. Maize

Due to its importance as the primary food crop in the region, maize warrants consideration for regional action. Two thematic areas are prominent: agronomic research and input distribution. Traditional breeding and screening activities do not appear to be a high priority at this time, for several reasons. The CIMMYT maize breeder for ESA is located in Harare and works more closely with southern Africa; the private sector has not stepped in with an aggressive program for East Africa. A yield gap between farm and on-station yields that was growing at least until this past year indicates greater need for research on agronomy and enabling conditions. In Kenya, maize market liberalization is credited with increasing smallholder yields in high potential zones from 3 1/2 t/ha to 5-6 t/ha (anecdotal evidence). A number of high-yielding varieties and hybrids developed in Kenya are available from KSC, and adoption has been quite good, at least in high-potential areas. There is a lack of seed availability within the region, as this year Uganda in particular purchased large quantities of improved seed from Kenya.

The key area for short-term regional activities is distribution of improved seed. This could be carried out in the context of the input distribution thematic area discussed above, with hybrid maize as one of the top priorities. KSC, a consortium of national seed companies, or private-sector agents are the most likely facilitators of this action.

A second key area for short-term regional activities in maize is product development and marketing, carried out in the context of research in the food-technology thematic area discussed above.

A long-term agenda of maize germplasm improvement is important, even crucial to agricultural transformation in East Africa. Considerable progress is needed on varieties suited for sustainable production in low-input conditions on fragile soils. However, until CIMMYT posts a breeder to East Africa or Cargill activates a screening and testing program, there is little to recommend use of scarce SAATS resources in this area.

2.5.3.3. Potato

Potato is the second-most important food crop in the region, after maize. The PRAPACE network has had considerable success in the past in developing varieties resistant to the two major biotic stressors: bacterial wilt and late blight. However, these stressors continue to affect potato systems and additional work in this area, as well as farm management issues, is important.

Greater utilization of potato via food-technology research is also a key area; here PRAPACE, CIP and a food-technology network would have some important areas of collaboration. CIP has considerable expertise and capacity in food technology issues for potato. In conjunction with a food-technology thematic activity as discussed above, potato could be a top priority for early action along these lines.

The critical short-run constraint is capacity. The Rwanda war completely disrupted the potato program. PRAPACE is now awaiting the Directors' decision about moving their headquarters to Uganda. There is concern about having funding in place by March 1995 to do their second-phase planting.

2.5.3.4. Bean

Beans are an important crop in East Africa, particularly among smallholders. Although they are not a dominant staple food as maize or potato, beans are grown on a substantial area: 200,000ha in Ethiopia, 400,000 in Burundi, and 700,000ha in Kenya, for example; and over 3,000,000ha throughout East and Southern Africa (Wortmann and Allen). Beans are usually grown in low=input conditions, often intercropped. Women have primary (80-90 percent) responsibility for the bean crop in Kenya, Uganda, Burundi and Rwanda. Important constraints to East African bean production include fungal disease such as angular leaf spot; other biotic stresses; and low levels of soil nitrogen and phosphorus, particularly in the lower altitudes; among other constraints.

Farm-level impacts of alleviating these constraints can be considerable. For example, reducing the severity of angular leaf spot by 10 percent could increase yields by over 30 kg/ha for large portions of the bean-growing area. Similar gains may be achievable by alleviating bean-stem-maggot problems and increasing nitrogen and phosphorus availability.

It is unlikely that beans are a large enough crop in East Africa so that improvements can stimulate agricultural transformation. However, beans have considerable on-farm, urban and

export potential, and could make important contributions to an ongoing agricultural transformation. The importance of women's efforts in bean production suggests that work needs to be continued on improving smallholder women's access to inputs, particularly fertilizer; it also suggests that technical innovations which increase women's labor productivity (as well as yields) will be of central importance to potential adopters.

The bean research network has had some notable successes in increasing farm yields and incomes (Sperling et al.). These past successes and the articulation of target areas in which substantive progress and impact is possible are strong signals in favor of continued funding for this type of activity. The evolution of the network from a CIAT-controlled activity to one that empowers the network participants (yet draws on CIAT expertise) is also a positive signal.

2.5.3.5. Cassava, banana

The key problem here is movement of planting material, which can be addressed via the input distribution thematic area. However, there are also some research issues: e.g., banana is becoming more popular in Kenya, but KARI doesn't have funds or desire to redo the Ugandan research. It seems as if there is scope here for supporting Uganda and/or IITA as a pole for banana research and then using SAATS to help disseminate results throughout the region. This needs greater exploration—I have some additional materials which I collected on the trip, but have not yet had time to look through them.

Cassava is more problematical. It is not a major commodity throughout the region, but is very important in some areas and for some target groups. The network is to add a food-technology specialist which is probably the key area for this commodity. Again, I have some additional materials but have not had a chance to look through them.

2.5.3.5. Agroforestry products

The AFRENA network has been modified and expanded into the African Highlands Initiative (AHI), endorsed by ASARECA. The primary objective of this initiative is to maintain and enhance soil productivity. An additional, positive outcome of the AHI is that it is the first effort in recent history to coordinate across donors, IARCs and NARS at this level. To this end, ASARECA has decided to add $160,000 of SAATS funds to the AHI for FY95.

The contribution of the AHI to agricultural productivity increases is tenuous. Soil productivity is surely related to the sustainable output of commodities appropriate to the soil type, yet with only a few exceptions the AHI and surrounding documentation do not seem to be concerned with commodities or products. In addition, it is unclear if the AHI is compatible with the SAATS policy of picking the ripe apples first (see Plucknett).

My reaction would be to commend ASARECA for moving forward with an initiative in what they view as a critical area, and for moving forward with coordination of many of the actors

in the TDT system, via the AHI. However, I strongly suggest that funding via SAATS past FY95 be continued only with the idea that AHI will choose priority commodities and increase the productivity of these commodities in a way that stimulates or encourages agricultural transformation. These priorities should reflect priorities established by ASARECA and the potential for technical progress in the priority areas. The highlands contain most of the high-potential land in East Africa, and failure to stimulate transformation in the highlands almost surely means failure to transform. The stakes are high. AHI is neither the sole nor primary means of stimulating transformation, but it should develop a key role for itself and define the links between soil productivity and transformation in the immediate future if it is to vie for continued funding.

2.6. Program inputs

The issue of empowering Africans complicates the determination of inputs somewhat. Since the determination of priority areas is to be determined by African regional organizations and the national organization from which they are constituted, it would be premature to specify inputs for particular activities.

3. Additional socioeconomic issues

The five items specified on pp. 15–16 of the design-team scope-of-work are covered elsewhere in this document or in other design-team documents. Several more critical items are addressed in this section.

3.1. SAATS improvements over prior technology paradigms

There are two critical distinctions in the SAATS paradigm: the development philosophy, and the targets for contributing to agricultural productivity.

3.1.1. An improved development philosophy

The SAATS development philosophy targets agricultural growth through linkages with the nonagricultural sector, and through reducing the cost of food and other consumer goods. The primary target clientele of the SAATS activities are consumer, most particularly the smallholder family as consumers and often net purchasers of food.

The perspective on the consumer and on the transformation of agricultural produce into consumer goods, whether in the farm household or in post-farm-gate processing and marketplaces, leads to a demand-driven approach to TDT. Research and transfer efforts should be aimed at those improved techniques which are demanded by potential adopters, and development of new and improved products should be commensurate with the demands of those who will consume such products. Identification of such demands and opportunities for successful TDT leads to a commodity subsector viewpoint. Finally, the recognition of the consumer as the ultimate user of agricultural products, and the history of the consumer as beneficiary of agricultural research, leads to a paradigm which explicitly recognizes and utilizes the importance of the consumer in stimulating agricultural transformation.

This paradigm is a solid contrast with earlier prescriptions for SSA, which relied primarily on increasing farm incomes as the means to economic growth. For example, Lipton argues that "most of SSA now offers smallholders no dramatic, immediately applicable new technology that might, with plausible increase in output/input ratios ... safely and substantially increase the profitability of food farming over large areas." While this is true, it has little to do with stimulating agricultural transformation. No country has ever gotten rich by having a vast majority of the population get rich from farming. Nor will SSA. SAATS places agricultural in its proper perspective: a sector in need of investment, but one that ultimately provides resources to the manufacturing, industrial, and service sectors.

3.1.2. Targets for contributing to agricultural productivity

Many policy discussion for agriculture in SSA give a growth target for the sector, usually in

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the 4–6 percent p.a. range; some also give a desired increase in productivity, but few explain how this productivity increase is going to come about.

Cleaver and Donovan discuss how to achieve a World-Bank target of 4 percent p.a. agricultural growth. They rely heavily on increases in inputs, including large increases in fertilizer use, and continued extensification (). For example, their combined land-labor input will grow at 1.8 percent p.a. Combined with technical progress (which is suppressed in their description), this will lead to a commensurate, 1.8 percent p.a., growth in agricultural output.

Table 2. Comparison of SAATS and World Bank Targets for African Agricultural Technology Systems.

FACTOR	GROWTH IN FACTOR	IMPACT ON OUTPUT/VALUE OF OUTPUT
WORLD BANK PARADIGM		
Land and labor	1.8	1.8
Fertilizer	10.0	1.0
Capital Stock	6.0	1.2
Rainfall	0.0	0.0
Sum of Impacts[a]		4.0
SAATS PARADIGM		
Land	0.0	0.0
Labor	2.0	1.0
Purchased Inputs	6.0	1.0
Technical Progress	2.0	2.0
Price Changes	-0.5	-0.5
Sum of Effects		
Output		4.0
Value		3.5

technical change incorporated into translation of inputs into outputs. Implicit technical change under CRS assumption is 1.1 % p.a. (authors calculation).

SOURCE for World Bank Numbers: Cleaver and Donovan.

The SAATS targets are more specific than the Cleaver and Donovan, and some differences appear. For example, SAATS does not target land-use growth, as this will conflict with NRM goals in many countries. The SAATS targets make explicit the contribution of technical change (increases in multifactor productivity), and the rate of price decrease. Nonetheless, the underlying analysis for the two sets of targets appears to be compatible. For example, if land

use was allowed to expand at 1.8 percent p.a. in the SAATS paradigm, then the need growth rate in productivity would fall to 1.4 percent p.a. This is still somewhat higher than the implicit growth in productivity in Cleaver and Donovan, due to the more rapid growth of fertilizer use and greater impact of fertilizer and capital in their approach. Overall, these general guidelines for targets seem to be compatible. As noted above, any targets will vary by agroclimatic region, socioeconomic conditions, and technical options.

3.2. Sustainability and its importance

Some polemicists argue that agricultural science, at least as it has been practiced, is an attempt to extract ever-increasing amounts of resources from the environment. They contend that such attempts are ultimately unsustainable, leading to the conclusion that there is a basic conflict between agricultural research and the environment. The historical record is in many cases contrary to this interpretation.

Within Africa, concern over natural resources has been a recurring theme. For example,

> Sahelian agricultural research programs considered soil degradation an issue in the 1920's (Reardon, 1994). The fragile base for dryland agriculture was a key theme which launched the CILSS and the Club du Sahel, and their paramount program, "La Lutte contre la Desertification" after the devastating Sahelian drought of the late 60's/early 70's (DeLattre and Fell 1984) [Catterson, p. 3].

Similar examples can be found in East Africa. The real debate is not environment v. agricultural (Catterson), rather it is over how best to harness the complementarities between environmental and agricultural management to generate technological progress that improves the (environmental and economic) welfare of the next generation of Africans.

It is especially important in Africa, because of the coincidence of severe poverty and resource-poor areas with fragile and degrading lands, that ANR management lead to sustainable practices that improve the livelihoods of the poor. "In Africa, the only way to boost production in pace with local food needs without having to cut more trees or plow up more land will be to move toward higher purchased input use and higher-yield farming (Paarlberg)." The key idea is that intensification often reduces rates of degradation (McGahey; Pinstripe-Andersen and Pandya-Lorch).

The SAATS project builds on those agricultural traditions concerned with increasing productivity in environmentally friendly and sustainable manners. The fundamental concept is that "unless environmental stability becomes a concern and joint undertaking of all concerned, agricultural productivity will not be sustainable (Catterson, p. 8)." SAATS explicitly recognizes that the key determinant of how man interacts with the environment is "the land-use management decisions made farmers, herders, woodcutters, etc. in pursuit of more secure and prosperous livelihoods. Affecting production and degradation means affecting these land-use

management decisions (McGahey). Building on complementarities between natural resource management (NRM) and agricultural research, NRM will play three roles in the SAATS activity: ensuring that development and transfer of sustainable techniques is based on sound NRM principles, incorporating considerations pertinent to alleviating environmental constraints to productivity growth, and providing guidance in setting research priorities (Catterson). The fruit of this interaction will be technology systems that stimulate sustainable growth in agricultural productivity.

Table 3. Illustrative comparison of sustainable and unsustainable innovations.

YEAR	SUSTN.	UNSUS.
1-8	-15	-15
9	18	100
10	36	200
11	72	400
12	144	200
13	216	100
14	252	50
15-30	270	1/2 of prior year
Cumulative effect after 40 years of 20 projects	5400	2
ROR	32 %	35%

Defining sustainable technology systems is not an easy task. Catterson argues that sustainability is ultimately defined by productive capacity: agricultural practices are sustainable if the do not diminish the productive capacity of the area in which they are practiced. Within a systems context, Meltzer agrees with this interpretation. But the definition of productive capacity or productivity must be accurate enough to incorporate all aspects of the natural resource system. That is, productivity must be defined not just with respect to marketable crops, but also with respect to intermediate products such as fodder, manure, straw for weaving, etc. A comprehensive definition of productive capacity incorporates concerns such as biodiversity--lack of biodiversity means that the system no longer has the capacity to produce certain flora and fauna.

However, simply maintaining productive capacity is not an indication of successful TDT. To be successful, TDT must actually increase the productive capacity of the system—or at least of one economically valuable component, while not denigrating the long-run capacity of the system or destroying less economically valuable components. Ruttan argues that "any definition of sustainability suitable as a guide to agricultural practice must recognize the need for enhancement of productivity to meet the increased demands created by growing populations and rising incomes (p. 401)."

The importance of sustainability of productivity increases is illustrated by examining the long-run effects of sustainable v. unsustainable innovations (in an abuse of the language we shall apply the adjectives

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sustainable and unsustainable to 'innovations' instead of to the effects of the innovations). In these illustrations, (?), each innovation is assumed to require an investment of 15 units per year for eight years prior to dissemination of results. For concreteness, each unit could be thought of as 0.01 percent of production value. The investment targeting sustainable productivity increases augments production by 18 units in the first year after dissemination, but by year seven and afterwards the augment to production is 270 units. It is this permanent increase in output which makes the innovation sustainable. Examples of such innovations may include investments in catchments for water harvesting, agroforestry and other forms of natural resource capital; and discovery of a high-yielding variety that becomes the parent of the varieties that improved varieties that replace it. The unsustainable innovation starts off with large impacts on production, 100 units in the first year, and reaches a peak increase of 400 units in the third year after dissemination. Thereafter the impact decreases by 50 percent every year. Examples of such innovations may include introduction of monocropping in low-input farming on unsuitable soils, or the development of high-yielding varieties that succumb to mutating biotic stressors. While each of the innovations generates high rates of return (RORs), with the unsustainable innovation having the higher ROR, the increase in production after thirty years of the unsustainable innovation is negligible. Even in the scenario in which the TDT system starts a new project for each of the first twenty years, after forty years the impact of the unsustainable innovations on production is almost negligible. In the case where the unsustainable innovations actually cause environmental damage, the impacts could even be negative. In contrast, the sustainable innovation generates continued production increases of 5400 units. Interpreting a unit as 0.01 percent of the value of production, investing 1.2 percent of production value per year in sustainable TDT leads to an illustrative increase in production of 54 percent, other things constant.

Finally, SAATS recognizes that adoption of sustainable "practices that increase production and reduce degradation cannot be mandated. Widespread adoption occurs when the appropriate set of incentives is established. A necessary task of governments, the private sector, and donors is to identify and establish those incentives (McGahey)." The contribution of improved techiques to this adoption is the identification, development, and transfer of productivity-increasing and degradation-alleviating techniques that will be demanded and adopted those agriculturalists making land-use decisions. The contribution of technology systems is to provide such techniques and the knowledge to use them, and to facilitate socioeconomic conditions in which these techniques can be adopted profitably.

3.3. Natural resource management issues

The current level of antagonism between agriculture and natural resource management is so unhealthy as to threaten both agriculture and the natural resources upon which it depends. NRM proponents correctly point out that vegetation stripping by land clearing, overgrazing, and fuelwood collection are the major causes of physical and chemical soil erosion in SSA. They are also circumspect about agricultural intensification that encourages nutrient mining and chemical soil erosion. A frequently cited example is the elimination of fallow is cropping

intensity rises (e.g., AFTEN). Proponents of agricultural intensification often view this concern as a brake on their activities. They correctly argue that increases in land productivity are critical in arresting degradation from extensification onto fragile lands, and that agricultural intensification is the clear and perhaps only choice to move SSA onto a positive economic growth path. For the most part, prior technology-systems activities have regarded productivity-enhancing

Regarding productivity-enhancing TDT and NRM as separate concerns is conceptually unsound. Morevoer, it fails to take advantage of the huge complementarities available between NRM and TDT: "the productivity and well-being of Africa's agrarian and pastoral peoples is directly linked to the wise use and conservation of the natural resource base (AFR/OTR, p. 1). SAATS will help to redress this lack orienting activities toward the development and transfer of sustainable and profitable technology: that is, toward knowledge and techniques that improve, or at least maintain, the potential of the natural resource base, while at the same time increasing farm-level productivity to encourage agricultural and economic development.

The link between TDT and NRM to be fostered by SAATS is a very practical one: "only the farmers and herders—planting tress, controlling erosion, nurturing soil and water resources, managing woodlands and rangelands with a view to direct economic benefits for their families—can begin to make the substantial impact required to reverse the decline and realize the full potential of the natural resource base (AFR/OTR p. 2).

SAATS will foster this link through two outcomes. First, the improved production techniques and products transferred will be required not to diminish the potential of the natural resource base. This is part of the idea of sustainable technology systems: that such systems help to sustain the natural resource base. Second, the techniques and products transferred will increase farm-level productivity. In addition to slowing extensification, increases in productivity make current resources more valuable. Thus, farmers and herders will have greater incentive to make investments in protecting those resources. For example, the yield response of improved varieties is often sufficient to make investments in ridging or other water-harvesting techniques profitable to the farmer; with traditional varieties, these NRM management techniques might not be used.

SAATS will achieve the confluence of outcomes by greater involvement and empowerment of farmers, herdsmen and villagers in setting TDT agendas and in natural resources planning and management.

3.4. The relationship with food security concerns

SAATS and agricultural technology systems are not designed to alleviate short-term food crises, such as those caused by drought or civil strife. They are long-term strategies to transform the economy in a more modern, more productive market-based system. This

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modernization will in and of itself alleviate the impacts of short-term crises by alleviating their severity. For example, a country that is capable of producing twice its food requirements has far more flexibility in responding to a drought that holds yields to one-half their average levels. Similarly, a productive and vigorous economy is likely to mitigate against civil strife, particularly if the vast majority of the population is participating in the economy and realizing gains in personal income and welfare.

Despite the difference in perspective between the SAATS long-term strategy and the immediate need for relief when a disaster strikes, there are some short-term, disaster-relief actions that are complemented by effective technology systems. The most notable of these is the preservation of knowledge and inputs to restore agriculture. For example, the Seed of Hope program for Rwanda would not work if there was no knowledge of what crops to grow or if there was a lack of seeds and planting materials. The effectiveness of research-based famine relief programs is well documented in the case of Operation Cowpea, a drought-relief program in Senegal in 1985 and 1986. This program generated an internal ROR of 31-92 percent. Yet it was a short-lived program that was not intended to change the structure of the farming system or to stimulate agricultural transformation. Thus, while SAATS is complementary to, can enhance short-term efforts to provide disaster relief, and contributes to a long-term strategy of food security, the SAATS vision is solidly grounded in economic growth based on agricultural transformation.

4. Criteria for selection of priority products

There are three main choices to be made in selecting priority products for SAATS activity: cross-commodity choices, choices of constraint or opportunity within a commodity system, and among the many possible solutions to the constraint and actions to take advantage of the opportunity. Criteria to inform the first two choices are addressed in this section. For the third choice, biophysical alternatives and choices will need to be discussed and made based on the commitments and capacities of the NARS and RARS (a set of technical criteria for identification of priorities is being prepared as a response to question 3 on p. 8 of the design scope-of-work by Plucknett and Powell); social-science alternatives are discussed in the section on social-science/policy networks.

4.1. Cross-commodity choices

While it is beyond the scope of this document to examine all the considerations necessary to make appropriate commodity choices, it is possible to suggest some ways of determining which commodities, given significant technological progress, have the greatest potential for contributing to agricultural transformation. That is, the document can make suggestions about where scientific achievement can most easily be translated into economic impact. This discussion in this subsection is based entirely on economic considerations, and does not reflect the possibility or probability of scientific achievement (or lack thereof).

4.1.1. Background

The current view of African agriculture in general and particularly WCA agriculture is one of severe problems (e.g., Eicher, Kaplan, Dommen). While there is considerable evidence that TDT has had substantially more success than the few with which it is credited (Masters and Sanders, Oehmke), pessimism is nonetheless the most common and widely-held perspective among donors, policy makers, and sometimes the research scientists themselves. Critics will debate the efficacy of any agricultural research effort. Some will condemn <u>any</u> FFA as unworkable and destined for failure.

Against this background of pessimism and prejudgment, it will be crucial to develop some successful research outcomes on a short-term basis, and that these successes be visible to participants in the agricultural sector (farmers, marketing agents, consumers, etc.), researchers, national governments, and donors. The criterion of quick, visible success should be included in the priority-setting discussion: this is the "low-apples" paradigm (Plucknett). This criterion is noted in the examples below.

The examples given here are based primarily on a desk study compiled in a relatively short time frame, with a modicum of follow-up in Africa. The specific crops were chosen by access to information, and do not represent the result of some implicit selection process.

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The specific criteria by which the examples are judged are selected on the basis of contribution to agricultural transformation, as discussed in sections 2 and 3, and on data availability.

The examples are not intended to, and are far from, providing definitive information for research priority setting. In particular, data on employment generation, especially in the post-harvest sector, and data on the effect of productivity increases on consumer prices are not available. National priorities are not yet available, and no attempt was made to examine technical capacity for and feasibility of research on the selected commodities. The examples are meant to illustrate the type of socioeconomic information that might be useful, and how that information might be used in a more thorough and formal priority-setting process. The reader should be cautioned that the illustrative results are unsubstantiated and subject to change.

4.1.2. Example: the use of regional socioeconomic indicators

Perhaps the simplest application of socioeconomic indicators is to characterize, in a gross fashion, distinguishing features of the national and regional economies and the contribution of agriculture to these economies. For example, differences in population growth rates between Burkina Faso and Cameroon—2.0 and 3.0 percent p.a., 1970-82, respectively (Table 4)—may affect the importance given to food crops for domestic consumption v. export crops. Additional considerations include the aggregate caloric deficit of 5 percent in Burkina Faso, and its prior ability to increase agricultural GDP faster than the rate of population growth. The relatively high proportion of the population living in rural areas in Burkina Faso, and the relatively large contribution of agriculture to GDP, may indicate the need for heavy emphasis on agriculture. The low, per-capita, agricultural GDP reinforces this need.

Table 4. Socio-economic and Agricultural Sector Indicators in Selected WCA Countries.

Indicator	Cameroon	Nigeria	Burkina Faso	Senegal	Sub-Saharan Africa	Year
GDP (mil US $)	7370	71720	1000	2510	-	1982
GDP per capita (US $)	819	788	143	418	-	1982
GDP growth rate (percent)	7.0	3.8	3.4(k)	2.9	3.0	70-82
Population (millions)	9	91	7	6	380	mid 82
Pop.-growth rate (percent)	3.0	2.6	2.0	2.7	2.8	70-82
Rural pop./ total pop. (percent)	63	79	89	66	78	1982
Primary commodity share of export (percent)	64	-	85	29	-	1980/81
Income (1970 — 100) (percent)	92 (m)	58	246	105	-	1979
Food share of merchandise imports (percent)	9	-	25	28	-	1980/81
Food aid (1000 ton)	10.5	1.4	82.4	77.1	2169	1982
Food aid (kg) per capita	1.2	0	12.7	12.8	5.8	1982
Agric. GDP share (percent)	27	22	41	22	33	1982
Agric. GDP (percent) growth rate	3.4	-0.6	1.4(k)	2.3	2.1	70-82
Agr. production (percent) growth rate per capita	-1.0	-0.2	0.5	-1.4	-1.1	70-82
Daily calorie supply per capita	2439	2361	2008	2434	2156	1980/81
As percent of requirement	102	91	95	101	90	1980/81

Source: Jahnke, Kirschke and Lagemann

A second type of socioeconomic information is commodity-specific. For the purposes of priority setting, it is useful to know the contributions of different commodities to food production, foreign exchange generation, and the creation of income and employment. Data are often available for the first two areas; but job creation in particular will be difficult to quantify with either secondary data or through primary data collection. A simple indicator of

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contributions of commodities to food production is the relative importance of these commodities in the current diet (Table 5). For example, the three commodities contributing most to the diet in Equatorial Africa and Humid West Africa are cassava, rice and maize. This is an indication that research to increase food availability should consider targeting one or more of these commodities. Research targeting increases in agricultural GDP should perhaps give priority to plantain/banana, as it is among the top three contributors to production value.

Additional socioeconomic indicators and discussion, based on the SPAAR/FFA reports, is available in the team report.

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Table 5. Priority Rankings of Food Commodities by Region and by Production and Diet Shares, 1979/1981.

EQUATORIAL AFRICA	HUMID WEST AFRICA	SEMI-ARID WEST AFRICA
RANKING BY VALUE OF PRODUCTION SHARE		
1. Plantain/banana	1. Yam	1. Yam
2. Sweet potato	2. Rice	2. Millet
3. Rice	3. Plantain/banana	3. Beef
4. Beef	4. Cocoyam	4. Cocoyam
5. Cassava	5. Oilpalm	5. Groundnut
6. Yam	6. Maize	6. Sorghum
7. Fieldbean	7. Groundnut	7. Sheep and goats
8. Maize	8. Beef	8. Cowpea
9. Groundnut	9. Cassava	9. Milk
10. Millet	--	10. Rice
RANKING BY CALORIES/PROTEIN SHARES IN THE DIET		
1. Cassava	1. Rice	1. Millet
2. Rice	2. Maize	2. Sorghum
3. Maize	3. Cassava	3. Yam
4. Fieldbean	4. Yam	4. Rice
5. Groundnut	5. Wheat	5. Maize
6. Plantain/banana	6. Plantain/banana	6. Cassava
7. Millet	7. Oilpalm	7. Wheat
8. Beef	8. Groundnut	8. Cowpea
9. Sweet potato	9. Cocoyam	9. Wheat
10. Wheat	10. Millet	10. Cowpea

SOURCE: Jahnke, Kirshcke and Lagemann, Table 3.2, pp. 39-40.

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4.1.3. Example: cotton in West and Central Africa

4.1.3.1. Overview

Cotton is grown and research on cotton is conducted in most of the WCA countries (c.f. Lele, van de Walle and Gbetibouo). Cotton is well suited to the drier areas in WCA, growing in rainfall as low as 300mm/yr if evenly distributed (Lele, van de Walle and Gbetibouo), and its multiple flowering allows it to generate output in slightly higher rainfall areas even if there are significant gaps in the rainfall pattern (Bosc and Freud).

In the 1960s the anglophone African countries, including Nigeria in WCA, produced 90 percent of Africa's cotton. In Nigeria, poor marketing policies and the oil boom precipitated a decline in production between 1970 and 1986 from 500,000 bales to 50,000 bales.[4] Following deregulation and privatization in 1986, Nigerian cotton production began a steady upward trend, reaching 300,000 bales in 1990 (Abdullahi). In francophone WCA,

> cotton is now a principal source of national income for countries such as Cote d'Ivoire, Cameroon and Senegal, and accounts for between 40 percent and 60 percent of the export trade of countries like Mali, Burkina Faso and Chad (Abdullahi, p. 2).

Current cotton-production techniques are input intensive, and cotton is usually grown in areas where chemical inputs are supplied by a parastatal. In most cases parastatal and research agendas have been geared to the smallholder sector.

The tradition of cotton research has generated some important payoffs:

> Cotton research in this zone has made advances along the entire commodity chain, combining objectives of yield increases (now 2 to 3 tonnes/ha of seed cotton in station), fibre and seed quality improvement, and higher fibre extraction rates (moving from 30 to 40 percent since 1960). Although chemical plant protection remains an integral part of the 'package', improved varieties are also less susceptible to a number of insects and diseases (Bosc and Freud, p. 33).

4.1.3.2. Feeding the population

As cotton is a cash crop, its contribution to feeding the population comes from increasing farmer incomes. In comparison to other crops and activities, returns to labor in cotton production are mixed (Table 6). In Cameroon, cotton grown with animal traction or mechanization generates impressive returns to labor. Similar evidence is available for Mali and Cote D'Ivoire (Barry). In Nigeria and Senegal cotton does not compete well with alternative opportunities, but these other commodities may not be viable, or may generate lower returns to labor, in cotton-growing zones. The average figures available from these countries probably mask differences in returns across soil-preparation techniques.

Table 6. Returns to labor from cotton and alternative agricultural and nonagricultural employment, Cameroon, Nigeria and Senegal (US$ per day, official exchange rates).

ACTIVITY	CAMEROON	NIGERIA	SENEGAL
COTTON:		1.05	1.85
Manual	2.85		
Animal Traction	5.45		
Motorized	7.39		
ALTERNATE CROPS:			
Sorghum/Millet	3.78	1.87	
Maize	4.52	2.84	3.00
Groundnuts	3.43		2.08
Rice	4.33	6.50	
ALTERNATE EMPLOYMENT:			
Farm Labor		5.59	
Hired Labor	4.77		
Family Labor	0.90		
Min. Wage, Private Sector	2.00		4.25
Min. Wage, Public Sector	1.73		

SOURCE: Excerpted from Lele, van de Walle and Gbetibouo, Table 11.

4.1.3.3. Generating foreign exchange

Cotton generates foreign exchange through exports. For example, "cotton is Cameroon's third largest agricultural export by value (behind cocoa and coffee) [Lele, p. 11, parenthesis in original]." In Senegal, cotton is the second largest agricultural export behind groundnuts. DRC ratios for Mali and Cote D'Ivoire are substantially less than unity for cotton grown with manual or animal traction (?), indicating that exports are efficient at generating foreign exchange. For mechanized production the DRC ratios are substantially in excess of unity. Even though mechanization increases returns to labor by reducing labor requirements per unit land, the purchase cost of investing in the machinery outweighs the savings from reduced labor requirements. Consequently it appears that only producers using animal traction are able to produce cotton at competitive prices to generate foreign exchange and still increase the returns on their labor.

4.1.3.4. Generating employment.

While hard data were not available within the time frame of this study, there is considerable evidence that cotton production is a high-quality, income-generating opportunity for large numbers of smallholders.

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4.1.3.5. Regionalization

The Compagnie Francaise pour le Developpement des Fibres Textiles (CFDT), created in 1949, is the parent company of the cotton parastatals in francophone Africa. The French state continues to hold a 64 percent equity position in the company, with CFDT equity participation in African-national parastatals ranging from 17 percent in Chad to 40 percent in Mali. The CFDT is actively involved in the provision of technical and managerial assistance to the African parastatals (Lele).

Research linkages between francophone and anglophone WCA are poor, as are linkages among anglophone countries (Adesina). Cotton research agendas are also different: francophone countries have concentrated on yield increases among smallholders, while anglophone countries have placed greater emphasis on quality (Lele).

4.1.3.6. The private sector

In francophone WCA cotton production is dominated by African parastatals related to the CFDT.

In Nigeria, private-sector involvement has been a key part of increasing production since the 1986. Private business has "undertaken the task of organizing and funding the purchase of seed cotton, processing and supply of its products (seed and lint) to manufacturers (Abdullahi, p. 2, parentheses in original). In technology development, the private sector has achieved breakthroughs in hybridization. Thus, "an important area of cotton research in which urgent cooperation between the public and private sectors is necessary is seed multiplication (Abdullahi, p. 5). In particular, there is a role for a regional action to establish quality standards for improved-variety seeds, and to help enforce these standards.

4.1.3.7. Additional issues

The nutritional requirements of cotton are high, so that it can leave improperly managed soil with little nutrient. While cotton is grown almost exclusively with application of chemical fertilizer (and manure), it is unclear if this is sufficient to prevent soil degradation:

> By far the most serious and controversial problem relates to the environmental impact of cotton. Major crises may be brewing in a number of countries, especially in francophone West Africa ...where the impressive growth of areas under cotton cultivation has been associated with deforestation, erosion, and soil exhaustion (Lele, p. 22).

4.1.3.8. Summary

Cotton has been an important commodity for generating foreign exchange and increasing

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returns to farm labor in smallholder conditions. Its adaptability to low-moisture conditions and tolerance to soil acidity gives it an advantage over many other cash crops. West Africa, especially the francophone countries, have well-established institutions for dealing with cotton and cotton research, linked at the regional level. The two problems with cotton are the declining world price and its affect on the environment.

Cotton could be a high-priority, cash crop on the research agenda. The primary role for the CMAWCA appears to be to provide better coordination and exchange of information across francophone and anglophone research groups.

4.1.4. Example: oil palm in West and Central Africa

4.1.4.1. Overview

Oil palm is an important oil crop in tropical, humid areas, and is indigenous to the tropical rain-forest of West Africa.[5] West Africa has exported palm oil and kernels to Europe since early in the 19th century. Commercial planting of oil palm started in Summatra and Malaysia in the 1910s; WCA began commercial plantings in the 1920s. World oil palm production has risen dramatically since WWII, with replanting of many Malaysian and Indonesian rubber plantations with oil palm, and renewed interest in the crop in Central and South America (Moll).

World production and exports of palm and palm-kernel oil are second among vegetable oils behind soybean oil (Moll). The primary WCA producers are Nigeria, Zaire, Cote D'Ivoire, and Cameroon, with Nigeria and Zaire substantially larger than the other two. Sierra Leone also produces a small amount of palm oil, primarily for domestic consumption, and other countries have scattered production. Africa has about 20 percent of world production but less than 3 percent of exports. These figures represent major declines from the early 1960s, when Africa accounted for 85 percent of world production and 60 percent of exports. The causes of the declines in market share are rapid expansion of production in Malaysia and Indonesia, and greater domestic consumption of palm oil within WCA.

Research has had some notable successes with hybridization. WCA yields on estates reach 3-4 t/ha, compared with under 1 t/ha for wild, local varieties. The improved varieties also have a lower proportion of saturated fatty acid (Bosc and Freud).

4.1.4.2. Generating foreign exchange

Thirty years ago there was reason to believe that oil palm could be a major producer of foreign exchange for WCA. With the growth of production in low-production-cost countries, notably Malaysia and Indonesia, it appears unlikely that oil palm will be a competitive export commodity for WCA. In addition, it is unclear that exporting palm oil provides net increases in foreign exchange, at least under the conditions in the mid 1980s. The domestic price of

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palm oil in Cote D'Ivoire and Cameroon exceeded the world price (Table 7). This price distortion caused net losses on exported product, and contributed to DRC ratios in excess of unity. Recent reforms will have ameliorated some of this distortion, but it is unlikely that WCA can compete in the world market.

Table 7. Use of domestic and imported resources and DRC, oil palm, Cameroon and Cote D'Ivoire.

COUNTRY	PRODUCTION & MARKETING COSTS, US$/t	IMPORTED INPUT COSTS, US$/t	F.O.B., US$/t	D.R.C.
Cameroon	451	70	358	1.32
Cote D'Ivoire	517	104	356	1.64

SOURCE: Moll.

Currently, WCA as a region is a net importer of oil palm (Lele). Consequently, there is a possibility of foreign exchange savings that can be generated by import-substitution. However, the DRC ratios must be brought under unity before any import substitution program can generate foreign exchange savings (DRCs will be lower than in Table 6 if calculated with oil palm as an import crop).

4.1.4.3. Feeding the population

Oil palm is consumed domestically in WCA. The expansion in area and production over the past thirty years has been sufficient to maintain producing countries' status as net exporters, but as a region WCA is a net importer. In addition, increased production of oil palm is correlated with and may be the cause of increased demand for the product: "In all countries where oil-palm cultivation expanded, oil palm became the major oil crop in a period of 20 years (Moll, p. 103)." Continued increases in population over the foreseeable future will put additional pressure on regional supplies probably leading to greater net imports. Despite this growth in consumption, the absence of oil palm from Table 5 indicates that at the regional level it is not all that important a food crop.

The low production and processing costs in Asia make it possible to meet the WCA population's demand for oil palm through imports. While this may appear enticing, the problem is the "unpredictable prices and fluctuations in the availability of imported oils (IITA p. 14)." Increasing dependence on world markets is likely to exacerbate this problem.

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4.1.4.4. Generating employment opportunities

There is little room for expansion of oil palm to generate employment for growing populations. There is a limited area in which oil palm can be grown competitively, as it is a moisture-intensive crop: "A precipitation of 100mm per month is about the amount required for evapotranspiration in tropical lowlands and monthly rainfall of less that suggests water shortage (Moll, p. 68)." The oil-palm areas are suffering from overcrowding, and the same agroclimatic characteristics desired for oil palm make production of other crops profitable.

> In Nigeria, the population density in the oil-palm areas reaches more than 300 people per square kilometer and under these circumstances semiwild oil palms are cut down to make way for food crops. ...In the southern parts of Ivory Coast and West Cameroon, population density is increasing fast because of high fertility and immigration, and it will become increasingly difficult to find large unused areas for estate development. Smallholders in these areas will eventually change to crops with a higher return per hectare if land becomes more and more scarce (Moll, p. 71).

Thus, as population increases lead to greater demand for employment, land suitable for oil-palm production will be devoted to other crops, possibly leading to decreases in regional production.

The need for refining, fractionating and further processing capacity is not apparent in West African countries, as the consumers are used to, or even prefer, the crude 'red' palm oil. Nevertheless demand for products such as margarine and colorless cooking oil is increasing and processing industries, generally covering all stages from crude palm oil to end-product, are being built or expanded. This may be an example of the profitable introduction of a new consumer-product into the food system.

There is considerable potential for increasing the quality of employment through increasing yields in WCA. Cameroon and Cote D'Ivoire produce about 2 t/ha, less than one-half of oil yields in Indonesia and Malaysia. The fertilizer response of oil palm is not definitively known, but there is at least some positive response (Moll). Smallholder production in WCA typically does not use fertilizer. Increased use of fertilizer and eventual development of fertilizer-responsive varieties and eventual replacement of traditional varieties may result in significant yield increases.

Gains in productivity can also be realized in post-harvest activities. Ginning ratios are low in WCA relative to Indonesia and Malaysia (Moll); while these are in part a reflection of the quality of the fruit, there appears to be some possibilities for post-harvest technical innovation. Additional efficiencies can be gained in marketing as WCA markets in general improve: "marketing costs will continue to decline—especially in African countries where there are still large reductions to be realized (Duncan, p. 9)."

4.1.4.5. Regionalization

Nigeria, Zaire, Cameroon and Cote D'Ivoire each have exported significant amounts of oil palm products in the past. Other countries in the region have often been net importers. Trade within the region may be economically feasible due to elimination of extraregional transport costs of products imported from Asia, although for port cities such as Abidjan it may still be cheaper to import than to transport from inland (readily available data are insufficient to address this issue).

Apparently due to the dominance of Indonesia and Malaysia, oil palm has not been given a high priority in national research, and consequently there is little regional collaboration. There is a regional producers' organization, the Association pour le Developpement du Palmier a l'Huile (ADPH), which "has expressed an interest in pursuing common research themes (Bosc and Freud, p. 30)." There is no evidence that follow-up activities have been undertaken.

There is a role for regional collaboration within the FFA. Most WCA countries face similar problems in productivity due to non-uniform annual rainfall distribution. Oil palm may also play a common role if reforestation activities are endorsed.

4.1.4.6. Additional issues

The value of oil palm to the farmer goes beyond the income earned from the fruit. Smallholders, in particular, produce "baskets from the leaves and soap from oil residue and ashes (Moll, p. 223)." In some areas palm wine is produced, and "[in the countryside there are also a variety of uses for the fronds (as fencing and roofing materials) and the byproducts of oil processing (shells are used as flooring material) (Bosc and Freud, p. 31, parenthesis in original)." In Nigeria, "oil palms are a major component of the [smallholder] farming system. Besides direct productive value, they are regarded as fixed assets, which can be pledged for loans or kept as a reserve for future requirements (Moll, p. 222)."

Oil palm can have a positive environmental effect in fighting deforestation. Cote D'Ivoire had a deforestation rate of 5.2 percent p.a. in the 1980s; Nigeria's was 2.7 percent p.a. (Cleaver). It would be important to determine if oil palm is economically viable when planted on more fragile lands, not so much for the oil it produces (it is not), but for the additional environmental benefits it generates. Development of varieties more suited for areas with unevenly distributed rainfall patterns may be important in stimulating agroforestry applications of oil palm.

Oil palm has a potential role in combatting soil degradation. In monocropping systems with few options for area expansion, farmers are acting to combat loss of fertility.

> In areas where fallow periods have virtually disappeared, under high population pressure and significant soil exhaustion problems, and the farming systems are dominated by pure cropping of maize, there is emerging evidence of farmers' adoption of alley cropping technologies (IITA, p. 3).

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Whether or not farmers will also adopt agroforestry systems to replace monocropping, and if so whether oil palm will be part of such a system, are important questions for which we do not have answers: "The preoccupation with introducing leguminous trees into the system may have precluded the consideration of integrating some perennials with economic value (rubber, oil palm) (Bosc and Freud, p. 55, parenthesis in original)." In parts of Nigeria where the population pressure is not so high, traditionally the wild "palms are intercropped with food crops such as cassava, yam and maize (Moll, p. 222)." It is uncertain if the farmer will replant oil palm on maize land once the wild palms have been cleared.

Soybean oil, the top vegetable-oil export in the world, may be a more attractive product than palm oil for parts of WCA. "Soybean is a relatively high-yielding and easy-to-grow crop in combination with other legumes (IITA, p. 13)." Nigeria and Ghana have released soybean varieties, and there is evidence of rapid uptake by farmers (IITA). As a legume with nitrogen-fixing capacity via rhizobium, soybean can have a positive environmental impact. This is especially the case in intensified, cash-crop maize production in the region: "Perhaps the most difficult, yet important challenge now being faced in maize cropping systems is to increase the efficiency of nitrogen recovery and use (IITA, p. 8)." Consequently, any decision about oil-palm research should be made in conjunction with decisions about soybean (and maize) research.

Palm oil also has industrial applications, mostly as a lubricant. However, if these applications can be expanded to include use as a fuel or fuel additive for internal-combustion engines, then there would be considerable demand for oil-palm and oil-palm products. WCA may not have any advantage in the research necessary to develop a fuel product, but should be ready to borrow and apply any results that are forthcoming from other sources.

4.1.4.7. Summary

Oil palm in WCA is not the export crop it was 30 or 20 years ago, and it is unlikely to regain this status. However, palm oil plays an important role in oil consumption in the region. In addition, oil palm has some potential to ameliorate the environmental impact of some farming systems, and can provide reasonable returns to labor. For these reasons, research on oil palm has the potential to generate consistent returns to research over a fairly long time frame. However, impacts will not be visible in the next decade, and even in the long run this commodity will not stimulate agricultural transformation in WCA. If it can complement other agenda items such as maize and soybean or agroforestry applications, oil palm would be an important inclusion on the research agenda, but it is not a top priority.

4.2. Choices of constraints and opportunities within the commodity subsector

The commodity subsector stretches from the inputs into farm-level production to the processing, shipping, distribution and final consumption of value-added agricultural products. Constraints at any stage of this subsector may hurt the performance at each stage of the

subsector. Therefore it is critical to focus on the weak links in the chain of products that constitute the subsector, to alleviate constraints and take advantage of the opportunities available by strengthening the weakest links.

One approach to identifying the weak links is a commodity-subsector-technology study, which is extremely similar to the tool known as industry analysis.

4.2.1. The commodity-sector-technology paradigm

Traditional commodity-sector approaches focus on social and economic activities and interactions among people (grain compiling, trading, milling) and thus typically lead to a perspective favoring social interventions to facilitate these interactions. While this perspective is not inherent in the commodity-sector concept, it is recurrent in applications of the concept. Consequently, emphasis is placed on donor and government actions to facilitate these socioeconomic processes, such as subsidized output prices to promote the selling process from farmer to wholesaler. Comparative neglect is given to the intermediate products—grain at the wholesale level is different from grain on the farm, not just because it is in a different position in the food system, but also because its physical characteristics may have changed during the intervening shipping and storage due to elapsed time—and consequently technical innovations that improve the quality of these products are relatively neglected.

The commodity-sector-technology paradigm focuses on intermediate products rather than the social interactions that coincide with intermediate production activities. Consequently it draws to the foreground the technical aspects of production and sharpens the focus on technological opportunity in the commodity sector. Two examples illustrate the differences and complementarities between the traditional and technological commodity-sector approaches. In the technology approach, grain stored on-farm for seed is an intermediate product different from grain stored for food. Recognizing this difference in products leads to implications about opportunities for technical innovation, e.g., insecticides may help prevent storage loss in seed but may make the grain unsuitable for human consumption, in effect causing a 100 percent storage loss in food grain. Complementarities are illustrated by the differences between the intermediate products of maize roller-meal and refined flour. The technological approach, recognizing these as different products, recognizes that they will have different end uses and thus discovers that they have different consumer audiences. The traditional approach, focussing on socioeconomic interactions, recognizes that different groups of consumer purchase processed maize products, and discovers that poor consumers are more likely to purchase roller meal (Takavarasha, Jayne and van Zyl), discovering the differences in the intermediate products. Implications for targeting research and policy toward poor consumers follow.

An illustrative commodity-sector-technology diagram emphasizes the multiplicity of intermediate and final-consumer products that are produced from raw products. ? depicts this idea for maize and cattle. The immediate outputs from maize production may be green maize,

grain, and fodder. Cattle may produce manure, milk, meat and cash if they are sold; other intermediate products such as land-tillage services may also be produced. Much as with the traditional commodity-sector approach, the technological approach traces these products through to the consumption of the final goods. Thus, maize grain may be refined into flours and sold in bulk by mills; these flours may then be packaged for retail consumption; and finally they may be purchased, cooked and eaten by the consumer. Similarly, milk may be used to produce butter, which in turn is used to produce baked goods, which are finally eaten by the consumer. Each intermediate product is given a place in the diagram, and at each step in the diagram a new intermediate or final product is introduced.

The commodity-sector-technology diagram is consistent with farming-systems and agroecological approaches. This compatible is implicit in the dashed lines in ?, indicating the impact of manure production on maize cropping and the availability of maize fodder on cattle production. A commodity perspective does not replace this farming-systems perspective, but it does add off-farm systems to the picture, enhancing the value of each perspective. For example, Meltzer finds that the nature of pastoralist livestock-farming systems influences the relationship between the milk and calves (which are intermediate products in the livestock-commodity system): "traditional production systems rarely provide supplemental feed during the dry winter months, and milk offtake for human consumption may stunt the growth of calves (Appendix B)." Another example of complementarities between the commodity-sector and farming-systems approaches is the recommendation to replace monocropped maize on marginal lands with other small grains needs to determine if the maize is being sold off-farm and then refined into flour, and if the other small grains can produce a refined flour of comparable quality. The need for grain meals and flours of particular characteristics may suggest important farm-level innovations, and farm-level opportunities may suggest new products that can find a niche in the commodity sector. The commodity-sector-technology approach provides a conceptual guide to determining where such possibilities exist.

4.2.2. Applying the commodity-sector-technology paradigm

The commodity-sector-technology (CST) paradigm emphasizes that the commodity sector is defined not by the raw agricultural output (e.g., maize grain), but by the panoply of intermediate and final products arising from the maize-farming and subsequent activities. Thus, this approach does not argue for (or against) breeding of improved varieties. Rather it seeks to examine which products can be improved in a way to generate the largest impact at the consumer level.

The CST paradigm facilitates the discovery of demand-driven opportunities for technical innovation. Since the demands of the final consumer drive the demands for the final and intermediate goods in the commodity system, the adoption of innovation at any stage in the system will be determined by demands throughout the system. The CST paradigm can help to determine these demands.

One outcome of this approach is to understand that considerable emphasis can be placed on

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off-farm opportunities. For example, in Zimbabwe 1/3 of the retail price of maize meal comes from value-added on the farm; 2/3 is from off-farm activities (Takavarasha, Jayne and van Zyl). If 1/3 of the maize production is sold as meal via retail channels, these figures suggest that 2/9 of the value of all maize produced is added in off-farm activities. As economies develop, this proportion grows until it reaches or exceeds 90 percent. Thus, there are significant opportunities in the non-farm sector for improvements in agricultural productivity that have an impact on a broad base of consumers, and that contribute significantly to generating value added and agricultural transformation.

References

AFTEN, 1992. Environmental Status Report Sub-Saharan Africa. The World Bank, Africa Region, Technical Department, Environment Division.

Badiane, Ousmane, 1993. The role of agriculture and trade in economic development. In Csaba Csaki, Theodor Dams, Diethelm Metzger, and Johan van Zyl, eds., Agricultural Restructuring in Southern Africa.

von Braun, Joachim and E. Kennedy, 1994. Agricultural commercialization, economic development and nutrition. IFPRI Food Policy Statment # 19(August).

Catterson, Thomas M., 1994. Integrating natural resource management concerns into agricultural research in Sub-Saharan Africa. SAATS position paper.

DeLattre, A. and A. M. Fell, 1984. The Club du Sahel—An experiment in international cooperation. Paris: OECD.

Johnston, Bruce F. and John W. Mellor, 1961. The role of agriculture in economic development. American Economic Review 51:566-93.

Leonard, H. J., 1989. Overview—environment and the poor: Development strategies for a common agenda. In H. J. Leonard, ed., Environment and the poor: Development strategies for a common agenda (New Brunswick: Transaction Books).

Lipton, Michael, 1988. The place of agricultural research in the development of Sub-saharan Africa. World Development, 16:1231-1257.

McGahey, Mike, 1994. Personal communication to Jeff Hill.

Mellor, John W. Food pice policy and income distribution in low-income countries. In C. K. Eicher and J. M. Staatz, eds., Agricultural Development in the Third World, 2d edition (Baltimore, Johns Hopkins).

Oram, Peter, 1991. Institutions and technological change. In S. Vosti, T. Reardon and W. von Urff, Agricultural Sustainability, Growth and Poverty Alleviation: Issues and Policies (Feldafing, Germany: Deutsche Stiftung fur Internationale Entwicklung).

OTR, 1987. Plan for Supporting Natural Resources Management in Sub-Saharan Africa. Agency for International Development, Bureau for Africa, Office of Technical Resources.

Paarlberg, Robert L., 1994. Sustainable farming: a political geography. 2020 Brief 4 (Washington: IFPRI).

Pinstrup-Andersen, Per and Rajul Pandya-Lorch, 1994. Alleviating poverty, intensifying agriculture, and effectively managing natural resources. Food, agriculture and the environment discussion paper 1 (Washington: IFPRI).

Schuh, G. Edward, 1990. Technical Change: Sources of Income and Agricultural Production in Developing Countries. In National Research Council, Board on Agriculture, Technology and Agricultural Policy (Washington, D.C.: National Academy Press).

Schultz, T. W., 1980. Nobel lecture: The economics of being poor. *Journal of Political Economy*, 88:639-651.

Staatz, John M., 1994. The strategic role of food and agricultural systems in fighting hunger through fostering sustainable economic growth. Michigan State University, Department of Agricultural Economics, Staff Paper 94-39.

Timmer, C. Peter, 1990. The agricultural transformation. In C. K. Eicher and J. M. Staatz, eds., Agricultural Development in the Third World, 2d edition (Baltimore, Johns Hopkins).

Timmer, C. Peter, 1994.

Tinsley, R.L., 1994. Rice Production. SAATS Position Paper.

United Nations (UN), Division for Economic and Social Information and Policy Analysis, 1992. Statistical Yearbook, 1991.

Weber, Michael T., J. M. Staatz, J. S. Holtzman, E. W. Crawford and R. H. Bernsten, 1988. Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue. *American Journal of Agricultural Economics*, 1044-1052.

Annex: Derivation of productivity targets

An aggregate formula for agricultural GDP is

$$GDP = PF(L, N, X) = P\tau L^{\alpha} N^{\beta} X^{1-\alpha-\beta}, \quad 0 < \alpha, \beta < 1;$$

where P is the price of the aggregate agricultural output, τ is a technology parameter, L is land employed in agriculture, N is labor employed in agriculture, and X is an aggregate of purchased capital and current inputs into agricultural production. The α and β are parameters.

The proximate determinants of the growth rate of agricultural GDP can be uncovered by differentiating the logarithm of each side of the equality. This results in

$$\hat{Y} = \hat{P} + \hat{\tau} + \alpha\hat{L} + \beta\hat{N} + (1 - \alpha - \beta)\hat{X},$$

where the hat denotes the percentage change in a variable.

In order to accomodate NRM considerations the desired target for growth in land inputs (area cropped) is set to 0. To generate the needed contributions of agriculture to the nonagricultural sector through low food prices, $\hat{P}$ is set to -1/2; this represents a decline in prices of 1/2 of 1 percent. The release of labor to the nonagricultural sector is modeled by setting $\hat{N}$ to 2, representing an increase in agricultural labor of 2 percent. With a population growth rate of 3 percent, this represents a release of 1 percent of the agricultural labor force. Parameter values are illustratively chosen to be α=1/3 and β=1/2. The parameterized equation is

$$\hat{Y} = \frac{1}{2} + \hat{\tau} + \frac{1}{6}\hat{X}.$$

It is now possible to search for combinations of $\hat{\tau}$ and $\hat{x}$ that result in GDP growth of 3 percent. Such combinations include $\hat{\tau}$ = 1.5,$\hat{X}$=6; and $\hat{\tau}$=2,$\hat{X}$=3.

Endnotes

1. The overall growth rate will be the weighted sum of the growth rates in the agricultural and nonagricultural sectors, where the weights represent the sectoral shares in GDP. Based on Timmer's calculation, an agricultural growth rate of 3 1/4 % p.a. is commensurate with a nonagricultural growth rate of 4 1/4 % p.a. The aggregate growth rate is thus $\frac{1}{4} \times 3\frac{1}{4} + \frac{3}{4} \times 3\frac{3}{4} = 4.$

2. There has been some confusion between the 4% target for economic growth, growth in agricultural GDP, growth in agricultural output, and growth in agricultural productivity. In the current document, every attempt has been made to specify precise targets for each of these indicators.

3. This process is distinctly different from structural transformation, which is the process of realigning government policies so that they are financially sustainable.

4. 181.43 kg/bale.

5. Oil palm is chosen as an example not only because information is readily available, but also because it is one of the crops on which the FFA task force has requested information, and in part because it provides a good illustration of the application of some of the concepts and criteria discussed earlier in the report.

Trip report

East Africa

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Trip report to East Africa

Purpose

The trip to Kenya, Ethiopia, and Uganda was made in support of the SAATS project design. The specific objectives were:

(1) to determine stakeholder interests in SAATS and in ASARECA as a vehicle for implementing SAATS

(2) to define high-priority components of a regional program for potential funding by SAATS

(3) to identify institutional pitfalls and possibilities in the implementation of the SAATS regional activity, drawing on lessons learned from previous activities in the region.

The report provides summary and conclusions with respect to each of the three objectives.

Stakeholder Interests

The primary stakeholders include NARS, IARCS, regional netwroks, private agricultural agents including farmers, private-sector associations and NGOs, and donors. Logistical constraints prevented interviewing of all relevant parties; a decision was made to emphasize interviews with NARS, IARCs, and donors.

Stakeholders interviewed unanimously support regional research and rationalizing regional research. Support for research activities is strongest in regional centers and in NARS, who believe that regional activities can be used to strengthen the national programs. Support for rationalizing regional reseach activities is strongest among the NARS and the non-research stakeholders in the technology system. NARS see extant regional programs as having failed to provide adequate support to the national programs, setting up "enclave activities" (ASARECA). Non-research stakeholders perceive a disjunction between research and farmers, processors, and other private-sector agents (KNFU, HCDA, USP). Although some progress has been made in making research more responsive to client demands (KARI, HCDA), the need for continued rationalization is substantial.

There is strong but not unanimous support for SAATS as a vehicle for supporting regional research. Support for SAATS is weaker than for regional research because 1) SAATS is poorly publicized, with some stakeholders in the private sector not having known of its existence before the interview, 2) the commodity subsector approach suupported by TAC and embodied in the AHL. The lack of a seminar-style presentation made it difficult to explain fully the approach, although the message that it is not a germplasm/breeding approach was sent forcefully. Complementarities between SAATS and the eco-regional approach were

discussed as deemed appropriate, particularly with donors supporting eco-regional approaches (e.g. the Bank).

Support for institutional innovation in SAATS such as foundations, endowments, consolidated funding mechanisms, and empowerment of Africans is mild at best. While interest in sustainable financing is considerable, support for particular mechanisms is withheld pending details on the mechanism and its implementation.

Empowerment of Africans through ASARECA received mixed reviews. NARS were quite accepting. Regional CG centers felt that NARS needed considerable strengthening and reform before they could become fully active partners (NARS also felt the need for strengthening, but thought this could come at least partially through regional activities, including networks and training). ICRAF felt that SAATS funds could be given directly to the centers. Other IARCs (CIAT, CIMMYT, CIP, IITA, ILCA) supported empowerment including control of funds, but questioned whether ASARECA had the institutional standing or technical capability to take control of regional activities.

The only area of general agreement about ASARECA is that if it does become empowered, it should support NARS development within a regional context.

Components

Three thematic areas were identified as high priorities for investigation as possible SAATS areas of concentration: social-science/policy research, input distribution and technology transfer, and food technology.

Social Science and Policy

There is considerable interest in a social-science/policy research network. Interest appeared both as explicit statements of support (IDRC, Mwangi) and in terms of expressed needs that are best addressed through such a network. Such needs includ help with priority setting (KARI), determination of key constraints to system performance (IAR, ILCA), identification of regional trade (KNFU) and input-market opportunities (USP), and assistance with financial management (Mugerwe), among others. CIMMYT has a long-standing committment to social-science research withing the FSR/E context in East Africa. They expect to continue this work under new funding from EU. IDRC is prepared to support research-priority setting at the ASARECA level, but funding is not immediately available. There is considerable interest by USAIDs in regional activites that will facilitate priority-setting at the national level, such as training workshops. A network would function most efficiently if it was coordinated with these activities. The priority-setting activity seems a natural on which a social-science/policy network could cut it teeth.

Input distribution

No stakeholder expressed satisfaction at the current state of input distribution systems (due to time constraints the stakeholder analysis did a poor job of internviewing extension-service representatives). A key area for regional action is the distribution of improved planting materials. For example, USp has access to no maize hybrids to reproduce and disseminate. Ugandan farmers apparently purchased large quantities of hybrids for KSC, leading to problems (for the first time) with seed quality and availability in Kenya (Hobgood). Regional coordination of planting-material distribution could improve the quality and timeliness of materials used throughout the region. Issues to be addressed include IPRs or other ways of protecting private-sector interests, particularly for those crops that do not rely or other ways of protecting private-sector interests, particularly for those crops that do not rely on hybrids; public-sector, NGO or farmer production and dissemination of high-quality planting materials for those crops or areas that the private-sector neglects; coordinating certification within and across countries (e.g., Uganda does not have a seed certification requirement), including phytosanitary analysis; facilitating transfer of planting materials across national boundaries; facilitating transfer to farmers; and exchange of information about the effectiveness of and potential demand for specific planting materials, to facilitate timely delivery of adequate supplies.

Food technology activity

There appears to be considerable potential for food technology research on a number of commodities, particularly in the areas of product development. Since food-technology research is an area neglected by traditional activities, specific products and product targets cannot be specified at this time. Needs can be specified. For example, smallholder potato farmers boil and eat most of their product; a small quantity is processed into potato chips for the hotel/restaurant market and some flour is consumed. The lack of processed potato products (mashed potatoes, potato pancakes, french fries, soups, etc) not only limits the market size, but also restricts varietal selection to those that have a sweet taste and so are more flavorful when boiled. Another example is maize, which is eaten primarily as Ugali, with few other options or porducts available (even though the Addis Ababa Hilton charges US$3.50 for a bowl of imported corn flakes). A third example is flours; low teff production in Ethiopia has led to use of njera made from a wheat-teff mixture; work on blended flours for njera as well as sorghum-wheat or other blends for European-style breads and bakery products has considerable potential. To be successful the food-technology research area should include complementary research on markets for innovative products to insure consumer acceptability.

Commodities

Livestock

The livestock subsector has the highest value of production of any agricultural subsector in East Africa, and affects large numbers of people. It also offers great potential for imporving the welfare of a large proportion of the farmers and herdspeople who live in marginal lands iwth limited crop potential.

Livestock systems are inherently regional. Participants in nomadic and semi-nomadic systems cross national boundaries at will, and much of the wildlife and livestock system in East Africa fits this pattern, such as tthe Masai Mara/Serengetti game park system that crosses the Kenya/Tanzania border, the Masai grazing system that crosses the same border, and the herding system stretching from northeast Kenya into Ethiopia and parts of Eritrea and Djibouti. Regional complementarities are also inherent in improvements in livestock and animal husbandry for mixed farming systems, since such improvements have the biological potential to be easily transferred across political boundaries.

It is unclear why livestock research has suffered from a relative lack of public funding. Possible explanations include a lack of political power among herders, who tend to live away from urban centers of power; appropriability of returns from breed imporvements by the private sector; conflicts betweeen farmers and herders; and lumping of livestock as a single commodity (v. the delineation of specific crops) to get a single dollop of funds. Within AID, support for livestock has declined because of a perceived lack of progress, although specific impact studies on livestock research are not available.

Livestock is a priority areas fro KARI and IAR based upon its importance ot Kenya and Ethiopia. Specific opportunities and targets for improvement are not yet available. The small ruminant CRSP seems to have had some success with smallholder dairy sysstems and is working on developing dairy cattle capable of plowing and tilling with minimal loss in milk production. Progress has been made in vaccine development. ILCA is currently in a livestock baseline study with which they hope to characterize the most important problems and the potential impacts of alleviating these problems.

Maize

Due to its importance as a primary food crop in the region, maize warrants consideration for regional action. Two thematic areas are prominent: agronomic research and input distribution. Traditional breeding and screening activities do not appear to be a high priority at this time, for several reasons. The CIMMYT maize breeders for ESA is located in Harare and works more closely with southern Africa; the private sector has not stepped in with an aggressive program for East Africa. A yield gap between farm and on-station yields that was growing at least until this past year indicates greater need for research on agronomy and enabling conditions. In Kenay, maize market liberalization is credited with increasing smallholder yields in high potential zones from 3 1/2 t/ha to 5-6 t/ha (anecdotal evidence). A number of high-yielding varieties and hybrids developed in Kenya are available from KSC, and adoption has been quite good, at least in high-potential areas. There is a lack of seed availability within the region, as this year Uganda in particular purchased large quantities of improved seed from Kenya.

The key area for short-term regional activities is distribution of improved seed. This could be carried out in the context of the input distribution thematic areas discussed above, with hybrid maize as on of the top priorities. KSC, a consortium of national sed companies, or private-

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sector agents are the most likely facilitators of this action.

A second key area for short-term regional activities in maize is product development and marketing, carried out in the context of research in the food-technology thematic area discussed above.

A long-term agenda of maize germplasm improvement is important, even crucial to agricultural transformation in East Africa. Considerable progress is needed on varieties suited for sustainable production in low-input conditions on fragile soils. However, until CIMMYT posts a breeder to East Africa or Cargill activates a screening and testing program, ther eis little to recommend use of scarce SAATS resources in this area.

Potato

Potato is the second-most important food crop in the region, after maize. The PRAPACE network has had considerable success in the past in developing varieties resistant to the two major biotic stressors: bacterial wilt and late blight. However, these stressors continue to affecto potato systems and additional work in this area, as well as farm management issues, is important.

Greater utilization of potato via food-technology research is also a key area; here PRAPACE, CIP and a food-technology network would have some important areas of collaboration. CIP has considerable expertise and capacity in food technology issues for potato. In conjunction with a food-technology thematic activity as discussed above, potato could be a top priority for early action along these lines.

The critical short-run constraint is capacity. The Rwanda war completely disrupted the potato program. PRAPACE is now awaiting the Directors' decision about moving their headquarters to Uganda. There is concern about having funding in place by March 1995 to do their second-phase planting.

Bean

Beans are an important crop in East Africa, particularly among smallholders. Although they are not a dominant staple food as maize or potato, beans are grwon on a substantial area: 200,000 ha in Ethiopia, 400,000 in Burundi, and 700,000 in Kenya for example; and over 3,000,000 ha througout East and Southern Africa (Wortmann and Allen). Beans are usually grown in low-input conditions, often intercropped. Women have primary (80-90%) responsibility for the bean crop in Kenya, Uganda, Burundi, and Rwanda. Important constraints to East African bean production include fungal disease such as angular leaf spot; other biotic stresses; and low levels of soil nitrogen and phosphorus, particularly in the lower altitudes; among other constraints.

Farm-level impacts of alleviating these constraints can be considerable. For example, reductin the severity of angular leaf spot by 10% could increase yields by over 30 kg/ha for large portions of the bean-growing area. Similar gains may be achievable by alleviating bean-stem-maggot porblems and increasing nitrogen and phosphorus availability.

It is unlikely that beans are a large enough crop in East Africa so that improvements can stimulate agricultural transformation. However, beans have considerable on-farm, urban and export potential, and could make important contributions to an ongoing agricultural transformation. The importance of women's efforts in bean produciton suggests that work needs to be continued on imporving smallholder women's access to inputs, particularly fertilizer; it also suggests that technical innovations which increase women's labor productivity (as well as yields) will be of central importance to potential adopters.

The bean research newtork has had some notable successes in increasing farm yields and incomes. These past successes and the articulation of target areas in which substantive progress and impact is possible are strong signals in favor of continued funding for this type of activity. The evolution of the network from a CIAT-controlled activity to one that empowers the network participants (yet draws on CIAT expertise) is also a positive signal.

Cassava/banana

The key problem is movement of planting material that can be addressed via the input distribution thematic area. However, there are also some research issues: banana is becoming more popular in Kenya, but KARI doesn't have funds or desire to redo the Ugandan research. There is scope here for supporting Uganda and/or IITA as a pole for banana research then using SAATS to help disseminate results throughout the region. This needs greater exploration.

Cassava is more problematical. It is not a major commodity throughout the region, but is very important in some areas and for some target groups. The netweork is to add a food-technology specialist which is probably the key area for this commodity.

Agroforestry products

The AFRENA network has been modified and expanded into the African Highlands Inititative (AHI), endorsed by ASARECA. The primary objective of this intiative is to maintain and enhance soil productivity. An additional, positive outcome of the AHI is that it is the first effort in recent history to coordinate across donors, IARCs, and NARS at this level. To this end, ASARECA has decided to add $160,000 of SAATS funds to the AHI for FY95.

The negative aspect of ASARECA is that its contribution to productivity increases in tenuous. Soil productivity is surely related to the sustainable output of commodities appropriate to the soil type, yet with only a few exceptions the AHI and surrounding documentation do not seem to be concerned with commodities or products. In additiona, it is unclear if the AHI is compatible with the SAATS policy of picking the ripe apples first (see Plucknett).

My reaction would be to commend ASARECA for moving forward with an intitiative in what they view as a critical area, and for moving forward with coordination of many of the actors in the TDT systems. However, I stronly suggest that funding via SAATs past FY95 be priority commodities and the idead that AHI increase the productivity of these commodities in a way that stimulated or encourages agricultural transformation. The highlands contain most of the high-potential land in East Africa, and failure to stimulate transformation in the highlands almost surely means failure to transform. The stakes are high. AHI is neither the sole nor primary means of stimulating transformation, but it should develope a key role for itself and define the links between soil productivity and transformation in the immediate future if it is to vie for continued funding.

Institutional issues

The most commonly cited institutional issue was accountability for finances and impact. Particularly with respect to ASARECA, there were questions from the IARCs abou the legitimization of the organization: when would it receive funds, howe would it disburse them, who would be accountable, etc. The NARS were interested in improving their own financial management practices, both to make them more compatible with tightened donor requirements and to provide better internal guidance about how and where money were spent.

Impact sustainability is a new rule demanded by donors and host-countries as well. The requirements that TDT sysems be accountable for people-level impact forces a broader perspective on biophysical scientists, who in the past have been held responsible only for scientific accuracy and integrity in their activities. This has led to considerable criticism of the scientific comunity for engaging in experiments of only academic interest, or for letting important innovations remain shut up in the laboratory rather than ushing to have them put in the field. The new emphasis on impact remains a sticking point with some scientists, who feel that they are now being judged on criteria not in place at the time they started their research agenda. NARS are wondering how best to deal with impact assessment and are concerned about building impact assessment and socio-economic monitoring into the projects from the start-but they are requesting help in so doing. A frequent suggestion (by both NARS and donors) was to hold regional training workshops in impact assessment and priority setting.

NARS and IARCS seem to have differenct opinions as to personel choic for networks. IARCs and networks naturally want to work with the best and most experienced NARS counterparts. NARS are faced with the dilemma of trying to maintain some sort of hierachrch based on seniority, while at the same time using networks as an oportunity for young scientists to hone their skills. Particularly when opportunities for per diem or other income is available, the senior scientists are most frequently associated with the networks. In some cases these scientists are picked for seniority and not their skills; in other cases networks may not want to work with young scientists who are still cutting their teeth. A common complaint among IARCs is that NARSdon't have the intellectual capacity to be full partners in networks.

A common complaint from the IARCs about running networks and other regional activities is

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that such an arrangement would foster unproductive competition (although the logic behind these arguments often escaped me). Three types of competition were cited: 1) competition among IARCs for funds, 2) competition between NARS and IARCs for funds, and 3) competition between IARCs to work with the relatively few qualified NARS scientists (although ILCA thought that getting young scientists involved was more problematical). The first seems to be no bigger a problem under ASARECA than under any other institution; the establishment of transparent priority and proposal guidelines within ASARECA would go a long ways to ease these fears. The second issue needs to be considered carefully in setting up guidelines for regional activities: if either NARS or IARCs (or other institutions) take chauvinistic approaches to using these funds for their own political or financial agenda, then there wil be a high likelihood of failure. The third issue is perhaps what instigated the classification of previous programs as enclaves. It can be avoided by allowing NARS (not IARCs) to specify the host-country counterparts; this must be accompanied by NARS commitments to provide adequate human capacity to the network and training to bring overall capacity up to standards, and by IARC commitments to facilitate such human-capacity development.

Interestingly, relatively little was said about competition with the private sector.

General questions about insitutionalization of networks included how to get greater transparency in programmatic and personnel choices; how to get better tracking, measurement, and publicization of impact; and how to establish the bureaucratic ability (in donors, NARS and networks) to take decisions sequentially in a fashion that move forward with a long-term vision of development.

A useful suggestion was to specify particular individuals as members of steering committees, working groups, etc., rather than appointing a country or NARS to send an individual. The former approach avoids having as new members at each meeting a substantial portion of the governing body, so that last year's decision do not have to be explained or retaken, and movement toward a long-run vision can be rapid.

Concerns were voiced about funding interruptions, both as the four AID-sponsored networks move into ASARECA jurisdiction, and more generally. A feasible suggestion is to move forward the decision date about extension to allow for a two-year time lag between a termination decision and the termination date. ILCA gave an example of one 4-year project that was subject to review after two years. This midterm review itself lasted two years, during which time ILCA picked up maintenance expenses from core funds. The project was then approved for the second two years of existence, so that a four year project took six years to complete.

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Trip report

West Africa

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West African Trip Report

1.0 West African Stakeholder Survey

1.1 Background

This survey attempts to identify potential beneficiaries, interest groups and participants in a regional agricultural development and transfer program. Discussions focused particularly on the institutional aspects of regional collaboration. The views of stakeholders were solicited on priority needs with regard to national and regional action and issues constraints and opportunities with regard to improving regional cooperation.

1.2 Methodology

The West African Stakeholder Survey was implemented by two members of the SAATS design team accompanied by one of the USDA RSSA personnel from the TDT component of the PARTS project from September 13 to October 2, 1994. This team traveled to Niger, Mali, Cote D'Ivoire, and Senegal. The team met with NARS leaders, USAID mission and REDSO personnel, IARC staff, personnel from USAID projects working in TDT, and some NGOs. INSAH brought together a number of NARS scientists to meet with the team. An informal interview guideline had been prepared in advance and was used as the basis of the different interviews. The exact questions varied depending on the audience and the time available. In each case a questionnaire which formed part of the interview guideline was left with a fax or Email number in case interviewees wanted to make additional comments.

1.3 Findings

Organizations
There is no single organization which specifically groups the 23 countries of West and Central Africa, in general, or in regard to agricultural research and technology transfer. CILSS and INSAH serve these respective functions for the 9 countries in the Sahelian subregion. There is no similar political institution for the coastal (humid) subregion and no organization is resoponsible for the coordination of agricultural technology development and transfer in the coastal subregion. ECOWAS has an agricultural committee, but neither the committee or ECOWAS in general are considered very effective. CORAF regroups the Francophone Agricultural Research Directors and sponsors certain networking activities. But CORAF has only recently begun to integrate the Anglophone countries, has not yet dealt with the integration of Nigeria, and is considered to be too strongly influenced by French representatives to provide an appropriate basis for local governance. To date, the IARCs serving in the region have served as an institutional base for organizing regional agricultural research. The principle of

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embowering Africans to govern their own institutions requires that SAATS search for a new institutional base.

The government institutions visited by the team consisted primarily of the National Agricultural Research Institutes. Attempts to interview other members of the Ministries of Agriculture were generally not successful. In several cases, personnel in projects related to agricultural TDT were also interviewed.

Interviews were conducted with personnel from several national and international NGOs particularly regarding their involvement in technology transfer. Interviews were also held at CIRES, which is the premiere social science research institute in the region.

1.3.1 Overview of stakeholder perceptions of regional issues, constraints and opportunities for improved regional cooperation

Perhaps the strongest and most consistent message from West Africa was the need to empower African institutions to make decision, set priorities and allocate funds which are to be used to benefit West Africans. There is strong agreement that regional activities should be based on national development objectives and priorities based on identifying common problems, constraints and opportunities across a number of countries.

The regionalization of research was supported by Agricultural Research Directors, who have been involved in SPAAR, INSAH, CORAF, and other regional activities. They perceive regional programs as supporting NARS if Africans are empowered to govern the decision-making institutions. In many cases there is a large gap between the knowledge of the Directors and their researchers with regard to regional programs. Frequently NARS researchers contacted had little knowledge of regional research activities and their organization. In several cases the Directors took advantage of our meetings to inform researchers about the SPAAR initiative and plans to establish regional institutions under the FFAs (INSAH meeting, IDESSA meeting). NARS researchers often suggested that the NARS are the priority research institutions and that funding should be channelled directly to the NARS. They found a regional research approach acceptable as long as regional efforts support and strengthen NARS, rather than replace them, and are based on strategies defined at the national level. With the exception of Mali, NARS representatives indicated that they often had difficulty obtaining financing for research projects and that their institutions faced severe financial constraints.

NARS representatives agreed that regional strategic planning should be based on common national objectives and that NARS representatives should be empowered to govern the regional organizations. Most researchers appreciate the efforts of the IARCs working in the region. However they felt that IARCs should provide services to national programs rather than directing national efforts through their control of network funding. Researchers felt that national representatives rather than IARCs should be responsible for the governance of

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regional institutions and the allocation of financial resources to activities.

NARS representatives were very positive about the contribution which improved agricultural research and technology transfer could make to economic development. They supported the demand oriented approach of the SAATS Initiative. However, demand was rather narrowly defined as responding to the needs of farmers. Interviewees regularly cited the farming systems related concepts of needing to make technology more relevant by responding to the needs of farmers and to improve the transfer of results to farmers. Some mentioned the need to work more closely with NGOs and other private sector groups to broaden and improve the transfer mechanisms. Responding to the needs of actors in the post-harvest area and market demands was less a part of their vocabulary. NARS representatives also cited the need to improve input delivery sysems and commercialization of products to enhace the production environment. There was little indication that researchers had thought about trying to predict what the market opportunities might be in 5 to 15 years.

The reaction of researchers to the "dirt to shirt," production to consumption definition of a commodity subsector was less clear. Researchers recognize the usefulness of a systems approach and the need for inputs and market systems to support commodity production. However, researchers are not accostomed to thinking that they need to do research on non-production aspects of the system. There is little in their institutional culture that indicates that they need to work with, or have much in common with private sector and other actors in input and product marketing, processing other post-harvest aspects of the commodity subsector. In most cases, their training and institutional culture is to focus on production.

1.3.2 Stakeholders Priorities for possible regional action

Stakeholders did not present clear priorities with regard to commodities or thematic areas which should be the focus or regional actions. The priority commodity or thematic areas suggested by researchers (and other interviewees) tended to reflect their discipline and area of research, as well as their country's climate conditions. There was agreement that maize, rice, and livestock are important throughout West Africa. Sorghum, millet and cowpea were cited as important in dryer areas while roots and tubers and tree crops are important in humid coastal areas. Natural resource management in general, and soil and water conservation in particular, was often cited as an area that needed more attention.

Researchers tended to promote an ecoregional approach to regionalization. However, most agreed that in West Africa the marketing opportunities are between ecoregions. This trade between regions is perhaps most obvious for livestock, but also true for fruits, root crops, vegetables, and processed goods.

For NARS researchers, the primary role of regional activity is to provide networking in the form of peer interaction and information exchange. Peer may be defined either within a discipline (agronomy, entomology) covering a group of related crops or pertain to a specific

commodity. There was little mention of needing to expand the interaction to all actors in a commodity subsector, or to increase exchanges between social scientists and physical scientists. While they recognize the need for improved input delivery, processing, marketing and policy, it was not clear that they recognized any need for a commodity research network to expand to include these other aspects. For the most part, NARS researchers familiar with the maize, rice, and sorghum networks funded under parts were satisfied with the manner in which they function, with one exception. That exception is that regional activities should be governed by representatives of the countries in the region and not controlled by the IARCs.

NARS directors had a broader view and supported collaborative networks which make use of joint planning and rationalize and share tasks among country programs. NARS directors mentioned the need for research on policy issues, on post-harvest constraints such as processing, transportation and marketing, and on improved sustainability and natural resource management. All NARS representatives were supportive of efforts to improve the stability of funding to national and regional institutions. Sahelians suggested that INSAH provided a forum which could serve as a regional coordinating organization. Coastal representatives were not convinced that INSAH was an appropriate forum to represent their interests, but had no alternative to offer.

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List of persons contacted

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Persons and stakeholders contacted

East Africa

Kenya
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Technical issues

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Technical issues

The following twelve issues were addressed by the design team during the SAATS project design.

1. Targets (short- and long-term) for growth in agricultural productivity (necessary to support sustainable economic growth of 4 percent per annum) must be determined at subregional level for Africa.

2. The SAATS Initiative will focus on those commodity systems and themes with the prospects for meeting the agricultural productivity targets necessary to support economic growth. An improved understanding is needed of what commodity systems have such prospects in the short and long term, as well as what constraint areas within the commodity system offer the greatest potential for getting increases in productivity. This information is required to bring a focus to the use of SAATS resources.

3. Economic and technical criteria must be identified that can be used to help identify priorities for research that establish the link with the interest of consumers and, concerns for sustainability of the resource environment.

4. Sustainable funding of national and regional systems is necessary to build sustainable institutions. The mechanisms and options with regard to the source of funding must be better understood and build into new programs. These new mechanisms shall avoid arrangements that establish notions of "entitlement" to resources; and shall encourage competitive funding along with creativity and accountability among individual researchers.

5. Resource requirements and investment levels needed to sustain and meet productivity and growth targets to be determined.

6. The integration of resource conserving characteristics into technology will require adjustments in the research process. A better understanding is required of how this can be done, what those characteristics are, and how their impact can be measured.

7. The SAATS Initiative is a regional program, and will support subregional grouping and collaboration. Indicators and measures must be identified that clearly describe the impact and benefits from regional, national and institute level activities that can be integrated into the progress monitoring and impact assessment plans of the SAATS supported programs.

8. To improve the availability of and access to technology several fundamental strategies might be used in Africa. For example, (a) establish a self sufficient national capacity, to support local development, adaptation, validation and transfer of technology, (b) import technology from external sources, local efforts concentrate on transfer of

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technology, or (c) import technology, local capacity focuses on adaptation, validation and transfer. The use of a particular strategy will differ largely, from one commodity system to another. And, different strategies might be used for different commodity systems in a single country. Guidance is required to assist policy makers, whether public or private, determine (i) what the most efficient strategy is for which commodity system, (ii) what the local stream of costs would be for the different strategies, (iii) what benefits and costs can be expected in the short and long term for these different strategies.

9. Commercialization of technology in Africa has been constrained by the trading infrastructure that facilitates access among technology users, the legal framework that facilitates and promotes investment in private technology transfer, the policy environment that influences the profitability of technology, and the legal framework that governs public-private sector interaction. Guidance is required to identify actions that can be incorporated into SAATS supported programs to address these issues and to encourage and facilitate commercialization of technology.

10. Rigid policies and procedures implanted in most African countries have limited the release and exchange of technology, as well as the exchange of information and expertise within and among the subregions. Guidance is required on steps that can be taken to improve and harmonize policies and procedures to speed up release and exchange, especially among countries within similar agroecological zones.

11. SAATS is, largely, an institutional development initiative. It is aimed at addressing the conditions unique to African technology systems. Management responsibility (e.g., Africa Regional or Global) of the SAATS initiative must be determined. Further, the role of REDSOs in management and monitoring must be clarified and appropriate support for these functions build into the SAATS financing plan including the suitability of existing Project and Contract instruments.

12. The implementation of SAATS will involve the development of new coalitions that do not exist at present, among IARCs, NARS, Universities, NGOs and private sector agents. These new coalitions will result, largely but not completely, from the consolidation of existing programs and activities. To support them will require the establishment of new governance and contract mechanisms that protect the interest of the various agents. And, that greatly improve/increase the role and responsibility of African national policy makers in providing leadership. The suitability of contract mechanisms that currently exist and are accessible through the PARTS project to support the SAATS Initiative must be closely examined.

Responses to these issues follow.

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Issue 1

Targets (short and long term) for growth in agricultural productivity (necessary to support sustainable economic growth of 4 percent per annum) must be determined at subregional level for Africa.

The subgoal of the SAATS project is:

Increased contribution of the agricultural sector to sustained economic growth.

This subgoal is one of two subgoals of AFR/SD for the ANR sector (the other being broad-based improvements in food security). The empirical underpinnings of this subgoal are found in two empirical observations. First, most Africans and most of the poorest Africans are employed in agriculture, and second, that there is a positive relationship between growth in the agricultural sector and growth in the nonagricultural sector.

Almost 1/2 of the population of SSA lives in absolute poverty (Pinstrup-Andersen and Pandya-Lorch). Most of the poor live in rural areas, often on fragile lands, and are employed in agriculture. For example, 67 percent of the labor force is employed in agriculture and only 9 percent in manufacturing (ASARECA, p. 11). The poorest of the poor often have insufficient land to meet their subsistence requirements (Leonard; Weber et al.).

The positive relationship between growth in the agricultural sector and overall economic growth is quantified empirically in Timmer, e.g., who finds that a one percentage point increase in the agricultural growth rate leads to an increase in the nonagricultural growth rate of 0.93 percentage points. In examining this relationship, Timmer finds that

> Several mechanisms can cause growth in agriculture to contribute directly to higher living standards for rural people while also stimulating growth in productivity for the entire economy... In combination, these mechanisms should translate faster agricultural growth into measurably faster economic growth in aggregate, after controlling for the direct contribution of the agricultural sector to growth in [gross domestic product] GDP itself (p. 22).

The potential contribution of agricultural to overall economic growth leads Timmer to conclude that the agricultural sector is the desired starting point for the development process.

Target

For SSA as a whole, the agricultural sector contributors 27 percent of gross domestic product (GDP). Along with Timmer's quantification of the relationship between agricultural and nonagricultural growth, this figure provides the information necessary for determination of the target rate of growth of agricultural GDP: 3 1/4 percent per annum (p.a.). This rate of

agricultural growth and the complementarity between agricultural and nonagricultural growth means that the economy as a whole is expected to grow at 4 percent p.a.[1,2]

Many of the poorest countries will gain more than 25 percent of their GDP from agricultural—for these countries, the figure will be in the neighborhood of 50 percent. As the agricultural sector is larger in these countries, so also must be its contribution to overall growth. If agriculture provides 1/2 of GDP, then the growth rate target rises from 3 1/4 percent to 3 1/2 percent p.a.

Further Issues

The importance of using agriculture to stimulate sustainable economic growth is summarized by Pinstrup-Andersen and Pandya-Lorch.

> Agricultural intensification addresses the root causes of poverty in many low-income developing countries: agriculture is the most viable lead sector for generating incomes and employment in both farm and nonfarm economies in most developing countries. ...agricultural intensification holds great promise as an instrument to simultaneously alleviate poverty, meet food needs, and avoid exploitation of the natural resources (p. 1).

It is clear that to contribute to the goal of broad-based economic growth, agriculture must not only grow at a sufficient rate, but must also contribute to growth in the nonagricultural sectors in a way that does not denigrate the natural resource base.

Consequently, it is crucial to delineate not just the 3 1/4 percent target for agricultural GDP growth, but also the contributions of agriculture to the 4 14 percent growth target for the nonagricultural sector.

The process through which agriculture contributes to overall economic growth is known as agricultural transformation or structural transformation.[3] Staatz describes the process of structural transformation as involving the long-run transfer of resources to the nonagricultural economy; greater reliance on markets rather than subsistence farming, due to specialization and exchange; and "increased access of individuals to knowledge systems of [the] wider world, as embodied in new technologies, management practices, and institutions (p. 4)." While in the long run there will be a voluntary transfer of human resources to nonagricultural production activities, in the short run, reliance on specialization, exchange, and new techniques and practices is facilitated by appropriate investment in the agricultural sector. Staatz goes on to argue that "the major policy issue is ...how to use investment in agriculture and the rest of the food system as a tool for transforming the structure of the economy, thereby increasing overall productivity and broad-based growth (p. 1)." Mellor argues that for countries whose economies are predominantly rural, "an agriculture-based growth strategy provides the only possibility of broad-based participation by the poor (p. 127)."

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The SAATS strategy for agriculture-led transformation gives three roles to the food system: to help people feed themselves, to stimulate nonagricultural growth, and to develop new products and services. People are better able to feed themselves if they are able to produce more for their own consumption, or if they able to generate additional income to have more flexibility in purchasing food. Four contributions from agriculture stimulate nonagricultural growth: release of agricultural labor to nonagricultural production, food production for the nonagricultural labor force, foreign-exchange generation, and purchase of nonagricultural goods by rural residents via market transactions (Johnston and Mellor, Staatz). The development of new products and services can contribute to income and foreign-exchange generation, and to enhanced exchange of agricultural and nonagricultural goods.

The role of the food system in helping people to feed themselves is inextricably linked to broad-based improvements in food security, which is a subgoal of the SD Agriculture and Natural Resources Sector goal (but not of SAATS because it is not in SAATS manageable interest—SAATS is not relief oriented and hence cannot respond to all of the short-term crises that impact food security). SAATS does contribute to an agricultural transformation that promotes this SD subgoal. This contribution is elaborated upon in the section 2.2.3.

The two fundamental characteristic of agricultural transformation most crucial to investment in sustainable technology systems are embodied in the release of labor to nonagriculture and the production of food for the labor force. First, it is impossible to increase food production and release labor without increasing labor productivity; it is nearly impossible to increase agricultural labor productivity without also increasing land productivity (yields). Second, production of food for the nonagricultural labor force means production, processing, transport etc. via a distribution systems that makes adequate quantities and qualities available at affordable prices. This requires productivity improvement in both the on-farm and off-farm components of the food system.

Issue 2

The SAATS Initiative will focus on those commodity systems and themes with the prospects for meeting the agricultural productivity targets necessary to support economic growth. An improved understanding is needed of what commodity systems have such prospects in the short and long term, as well as what constraint areas within the commodity system offer the greatest potential for getting increases in productivity. This information is required to bring a focus to the use of SAATS resources. Three thematic areas were identified as high priorities for East Africa investigation as possible SAATS areas of concentration: social science/policy research, input distribution and technology transfer and food technology.

The social science/policy research activity should focus initially on strategic planning processes for regional and national research organizations, then move to incorporate socioeconomic and policy information into the research and policy determination processes. A key area in input distribution for regional action is the distribution of improved planting materials. There are regional coordination issues and economies of scope and scale to be addressed. There is considerable potential for food technology research on various commodities, particularly in the areas of product development. The food technology research area should include complementary research on markets for innovative products to insure consumer acceptability.

The livestock subsector has the highest value of production of any agricultural subsector in East Africa and affects large numbers of people. It also offers great potential for improving the welfare of a large proportion of the farmers and herdspeople living in marginal lands with limited crop potential. Due to its importance as the primary food crop in the region, maize warrants consideration for regional action. Two thematic areas are prominent for maize: agronomic research and input distribution. Potato is the second most important food crop in the region. The PRAPACE network has been successful in the past in developing varieties resistant to the two major biotic stressors: bacterial wilt and late blight. These stressors, though, continue to affect potato systems and additional work in this area, as well as farm management issues. Greater utilization of potato via food technology research is a key area.

Beans are an important crop in East Africa, particularly among smallholders. Although they are not a dominant staple food as maize or potato, beans are grown on a substantial area: 200,000 ha in Ethiopia, 400,000 in Burundi, and 700,000 ha in Kenya, for example; and over 3,000,000 ha throughout East and Southern Africa (Wortmann and Allen). Beans are usually grown in low-input conditions, often inter-cropped. Women have primary (80-90 percent) responsibility for the bean crop in Kenya, Uganda, Burundi and Rwanda. Important constraints to East African bean production include fungal disease such as angular leaf spot; other biotic stresses; and low levels of soil nitrogen and phosphorus, particularly in the lower altitudes among other constraints. Farm level impacts of alleviating these constraints can be considerable. For example, reducing the severity of angular leaf spot by 10 percent could increase yields by over 30 kg/ha for large portions of the bean growing area. Similar gains may be achievable by alleviating bean-stem-maggot problem and increasing nitrogen and phosphorus availability.

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Issue 3

Economic and technical criteria must be identified that can be used to help identify priorities for research that establish the link with the interest of the consumers and the concerns for the sustainability of the resource environment.

The types of regional and subregional actions that SAATS will support fall into four categories:

1) establish regional coordinating mechanisms, including development of sustainable financing plans and mechanisms for collaborative regional programs that will increase national system governance and management of regional programs;

2) strengthen regional and national institutions through institutional innovation;

3) regional and national research, development and transfer activities to increase the flow and use of technology, including support for extant regional networks currently funded under PARTS, that are functioning effectively;

4) cross regional actions that are of benefit to national systems in different parts of the continent.

SAATS will help establish and strengthen regional coordinating mechanisms to promote and support governance that increases the role and responsibility of leaders of national technology systems (public and private) for regional programs. The increased attention to improved governance reflects an evolution of current regional and national programs to be more responsive to local stakeholders. The restructured or newly established regional coordinating mechanisms build on successes of past regional programs and the improved human resource capacity in African technology systems that have been developed over the past two decades. The principal mandate of the regional coordinating mechanisms is to facilitate a focussing and concentration of effort on regional themes and commodities that are a priority across the regions (in two or more countries). The regional coordinating mechanisms will improve donor coordination and continuity for priority programs. The coordinating mechanism will also provide a vehicle for sharing of experience and lessons from bilateral and national assistance within the subregions and, thereby, increase the value of bilateral assistance.

Interests of consumers

Continuous food supply to meet dietary demands of the household (rural subsistence producers, urban poor).

Low cost food (unprocessed and processed grains, fruits and vegetables, meat and milk) that is of acceptable quality, tasteful and nutritious (urban middle and upper classes?).

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Concerns for sustainability

Sustainable agricultural systems must remain productive over time. They should provide for the needs of current, as well as future generations, while conserving natural resources. The enhancement of the environmental quality and the resource base on which agriculture depends is viewed as a requisite to sustained agricultural productivity.

Technical criteria that establish the link between consumers and sustainability

Yield per unit of resource used

Any negative effects on the environment need to be costed. These effects may be soil loss due to erosion, soil organic matter and nutrient reductions etc. Costs should reflect long-term reductions in productivity and/or replacements using external organic matter and nutrient sources (e.g. fertilizers).

Energy efficient production

Inputs (fertilizers, fuel etc) are often costed according to their market value. This cost may not truly reflect the energy cost to the environment. As energy becomes more scarce and expensive it will become more desirable to focus research on production systems that are energy efficient (expressed in kcal/kcal).

Biodiversity

The greater the diversity (e.g. plants in natural pastures and fauna in soils) the more sustainable a production is. Production agriculture should seek to maintain or increase biodiversity.

Crop nutrient use efficiencies

Nutrient losses due to excessive and ill-timed applications increase both production costs and the risk of environmental pollution. Research that increases crop nutrient use efficiencies could raise yields, reduce prices and decrease the risks of environmental pollution.

Yield stability

Risks associated with rainfed agriculture in SSA are often great, especially in semi-arid regions. The characteristic high rainfall variability of the semi-arid zone causes large inter- and intra-annual differences in agricultural productivity. Subsistence farmers in these areas continue to rely on traditional crop varieties well adapted to local climatic and pest conditions. Plant breeding research needs to emphasize yield stability during periods of stress or large perturbations in climate. Yield stability could lead to more stable prices and food supplies for the poor and provide indirect incentives for producers to adopt farming practices

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that do not mine the soil of nutrients or cause soil erosion.

Harvest index (HI)

HI is the fraction of total aboveground crop production that is harvested for food. Traditional crop varieties often have low HIs and breeders seek to improve this. However, non-food crop portions (stems, leaves, brans, etc) provide animal feed, construction materials, fuel and/or mulch to protect the soil surface. Crop breeding programs need to consider the various uses of crops and their by-products. An excessive shift of the HI to food may be unacceptable to farmers unless alternative sources of feed, construction material and fuel are made available. A reduction in by-product yield and may also have negative impacts on soil erosion control and nutrient cycling.

Overgazing

Livestock provide meat and milk and stabilize food availability during years of low rainfall and inadequate crop production. However, continuous overgrazing and/or excessive harvest of vegetation for stall-fed animals can have negative impacts on the environment. Drought can devastate animal numbers. The stable provision of livestock products to consumers depends on technologies that buffer feed supplies and animal numbers during low rainfall and drought periods. Sufficient forages are needed to meet animal dietary demands and for soil conservation. Research on vegetation dynamics and management, and methods to maintain animals during drought addresses both consumer demands and concerns for preservation of natural resources.

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Issue 4

Sustainable funding of national and regional systems is necessary to build sustainable institutions. The mechanisms and options with regard to the source of funding must be better understood and build into new programs. These new mechanisms shall avoid arrangements that establish notions of "entitlement" to resources; and shall encourage competitive funding along with creativity and accountability among individual researchers.

Four innovative sustainable funding alternatives will be applied in the SAATS program. These are endowments, check-offs, debt for development conversions, and commercialization schemes. Each deserves elaboration.

One caveat is first in order. It is the justification for the use of host government (HG) funds from tax revenues for agricultural research programs. Under a competitive market system, the ultimate beneficiary of most agricultural research, specifically for domestic food consumption purposes, is the consumer. Granted, early adopter farmers will have some initial gains from the reduced cost per unit of output the new technology will yield. However, when the technology becomes accepted throughout the industry, all farmers' costs will reflect its impact, i.e., lower everyone's costs per unit of output. At this new, lower cost equilibrium, the temporary profit is no longer enjoyed by the early adopters. But the consumer enjoys a lower cost food supply, which in many developing countries is an important wage good. Hence, a broad-based tax program is justified for consumers as their way of insuring a continuation of the reduction in the cost of their food.

The SAATS program will explore the establishment of an endowment in selected regions. Endowments are especially useful when blocks of funds (e.g., from the soft currency sales of PW 480 Title III foodstuffs) need to be invested quickly in assets that appreciate with inflation. Further, they can be structured to provide a stable flow of income that can be allocated to highly promising research projects on a competitive basis. One Latin American foundation has chosen to invest part of its endowments in offices buildings, the rent from which funds its competitive grants program.

Another sustainable funding alternative to be considered by SAATS in selected situations is the use of check-offs. Although created and given oversight by government, these are voluntary programs administered by user groups. Usually administered at the point of first sale, these funds—which are very small relative to the value of the commodity—can generate appreciable quantities of funds when administered on an industry-wide basis. In turn, these can be used to fund a competitive grant research program.

A third funding alternative used in few African countries is debt for development conversions. Simply put, these enable holders of hard currency to leverage their funds into more soft currency than a conventional currency exchange would yield. This is done by purchasing nonperforming debt at a discount and, in turn, selling it to HG central banks for local currency, frequently paid out over the life of the project.

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The final nontraditional funding source that will be considered in selected African sites will be via commercialization schemes. Under this arrangement patent royalties are generated not only for the inventor but also the employing research institution. This alternative will be most attractive in highly monetized economies.

The first task in the sustainable funding portion of SAATS will be the determination of which of the four alternatives mentioned above will be initiated in each location. Subsequently, an effort will be mounted to establish the alternative of choice. Regardless of the one used, each can supplement the HG appropriated funds for agricultural research.

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Issue 5

Resource requirements and investment levels needed to sustain and meet productivity and growth targets to be determined.

Due to the nature of this project, and its emphasis on empowering Africans to set their own agenda, specification of the number and types of networks is beyond the scope of this design. Instead we have provided a boiler plate budget for a typical network assuming that the project would support 3-8 networks per region.

Total cost would be approximately $500,000 to $700,000 per year.

Network coordinator	$150,000
Network meeting	$ 50,000
Steering committee meeting	$ 20,000
Operating costs($25,000 * 12 countries)	$300,000
E-mail, phone, and other communication costs	$ 20,000
35 percent overhead costs	$189,000

In addition we expect that there will be expenses associated with project management.

Issue 6

The integration of resource conserving characteristics into technology will require adjustment in the research process. A better understanding is required of how this can be done, what those characteristics are, and how their impact can be measured.

Adjusting agricultural research to integrate resource conserving characteristics

Links between poverty and natural resource degradation are strong in sub-Saharan Africa (SSA). In efforts to increase agricultural production farmers are cultivating marginal lands and fallow periods are shortening and disappearing, resulting in soil "nutrient mining." Accelerated deforestation and overgrazing are also eroding soil productivity. Soil "mining" and degradation must be arrested if long-term gains in agricultural production are to be obtained. Sustainable increases in agricultural productivity imply that the productivity of the natural resource base is maintained or enhanced.

Farming techniques in SSA need to be modernized if long-term gains in agricultural production are to be attained. Improved crop varieties and fertilizers and good management techniques will not only result in greater yields, but can build-up soil organic matter and nutrient reserves and enhance the natural resource base. Poor management of such technologies can lead to nutrient leaching and runoff, and contamination of surface and ground water.

Crop, livestock and renewable natural resource management are inextricably linked. Many farmers in SSA keep livestock and continue to rely on manures for maintaining soil productivity. Although some of the nutrients contained in manure are derived from cropland (crop residues and by-products) most come from grazing of range and fallow lands. Degradation of these resources through overgrazing and excessive removal of vegetation for fuel, building materials, etc. jeopardizes the integrity of these nutrient cycles and the vital link between sustainable crop and livestock production and natural resource management. The importance of livestock in many production systems provides direct incentives to farmers (and researchers) for linking agriculture and natural resource management.

A shift from livestock husbandry based on grazing to one based on cut and carry and stall-feeding will alter nutrient cycling patterns in mixed farming systems and increase the potential of nutrient loss and pollution around stalls. The new demands for food and feed will increase the demand for fertilizers and require technologies that capture and recycle nutrients voided by stall-fed animals.

Whereas biophysical factors (soil, water etc) and their interactions directly effect commodity productivity, management factors largely influence the impact of agriculture on the environment. For example, soil erosion is often primarily due to socioeconomic and political factors such as land tenure, agricultural pricing policies, upslope migration, and the promotion of inappropriate technologies. This implies clear divisions and different approaches to

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research and technology development that result in sustainable increases in agricultural productivity and income and overall agricultural transformation.

How resource conservation can be factored into agricultural research.

The transformation of subsistence agriculture to commercial cropping systems can be fraught with difficulties. During the preliminary stages of intensification, inputs such as fertilizers and improved management systems may not be fully in place. This increases the hazard of nutrient mining, soil erosion and environmental degradation. For the many regions in Africa where preliminary agricultural intensification is on-going, there is an urgent need to provide inputs and advise on alternative management techniques if long-term environmental degradation is to be avoided.

Biophysical research needs to investigate land-use practices that are compatible with natural ecological processes. Interventions that mimic natural ecosystem processes also display high stability (eg managed fallows or successional cropping systems provide continuous plant or residue cover over the soil surface, and if they involve legumes and cereals, supply nitrogen to the cropping system; intercropping using crops of differing structure make efficient use of sunlight, water and nutrient source. Decreasing sustainability is often associated with management practices that disrupt natural ecological processes and are indifferent to the environmental specifics of the location.

Natural resource management practices are influenced by cultural perceptions of the environment, access to markets, opportunity costs of alternative land-use practices, the condition of the natural resources in the area, and community access to these resources. These factors evolve continuously with changes in land-use and agricultural development.

An understanding of the potentials and limitations of natural resource base is vital to delineating relevant goals and objectives for agricultural research. A simple technique such as preparing a land use map and comparing it with actual land use can act as a first step in setting priorities for agricultural research. Such a land use planning exercise can also provide the baseline for understanding the land-use choices of farmers and how they might be integrated or modified to foster a more sustainable local farming system.

An agricultural research program will have to focus not only on biophysical aspects of increasing agricultural production but also on the resources available to producers, how they are used rather than focusing just on the outcomes (ie., crop and animal yields). Taking these natural resource conditions into account can be an important first step towards identifying agricultural research priorities and potentials.

How impact can be measured

Monitoring the impact of technologies on natural resource requires first a point of reference, a measure of how the system is functioning, a comparison of the assessment with the reference.

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Indicators are not precise measurements. Instead, indicators are easily observed and understood assessments that either highly correlate with more precise and well-defined measurements or serve as proxy measurements, for changes in complex systems.

The choice of indicators for measuring sustainability and the information to be collected needs to be appropriate to program objectives and goals, the local environment, and to the level of accuracy required. Development, research and policy perspectives of sustainability, and therefore indicators for monitoring sustainability differ widely.

Changes in resource base status such as soil and water quality are indicators of sustainability. Examples of methods for assessing the sustainability of soil and cropping systems are:

Productivity: Production per unit land area or other resource. Production data provide information about resource quality and availability, management practices, and the economic status of the production system. However, there are often trade-offs between production gained due to intensification and expanding cultivated land areas and conservation and sustainability. Intensification without adequate inputs (fertilizers) can lead to short-term increases but long term decreases in productivity.

Nutrient Balance: Provides a general estimate of nutrient balance for fields, regions etc. If the difference between annual nutrient returns via organic materials, fertilizers and natural additions (rain, dust, soil mineralization etc) and annual nutrient removals through harvest of grain and crop by-products is negative, then nutrient mining and soil degradation is occurring. Production systems with negative nutrient balances are unsustainable and yields will eventually decline. If annual additions exceed removals, which is rare in SSA, then environmental pollution is a risk.

Soil Erosion Vulnerability Index: Uses soil water capacity, pH, bulk density and soil depth to determine a soils productivity index.

Erosion Sensitivity Index: A modification of the Universal Soil Loss Equation. It determines the maximum rate of annual soil erosion that may occur and still permit a high level of crop production to be obtained economically and "indefinitely." Examines how soil cover and management factors affect soil loss.

Coefficient of sustainability: The measure of change in soil properties in relation to production under specific management systems. It includes measures of output per unit input that maximizes per capita productivity or profit; output per unit decline in the most limiting or non-renewable resource; the minimum assured output. The time scale for these measures is important and must be clearly selected.

Agricultural Sustainability Index: A broad-based index based on several parameters associated with agricultural production. These parameters include productivity per unit input of the limited or non-renewable resource; the critical soil property e.g. soil organic matter,

rooting depth; available water capacity including water quality; climatic factors.

Total Factor Productivity Index: A cropping-systems level index that merges biological, physical, and economic measures into a single economic index

Linkage between increases in agricultural production and enhancement of natural resources

Soils in Africa are inherently infertile and prone to degradation and permanent loss in productivity if mismanaged. Few soil management alternatives exist for farmers. Farmers often realize the inherent limitations of their agricultural resource base and understand that additional investments are unprofitable in the short-term. Many lack the necessary means and incentives to invest in soil amendments that enhance productivity. Demographic pressures in many areas have forced them to abandon practices such as fallowing that traditionally improved soil fertility.

The productivity of many African soils is declining. Nutrient balances, or differences between nutrient inputs and removals, are negative for many farming systems. The substantial increases in agricultural production necessary for SSA can only be achieved through the use of soil amendments and improved management. Soil surface management such as tillage, soil cover and anti-erosion measures, and the application of fertilizers, manures and other organic amendments can enhance the production potential of soils that have an inherently low production potential.

Long-term increases in food production can only come from reversing the trend of nutrient mining. Fertility levels also need to be increased in those regions where farmers are maintaining soil productivity. Although soil fertility maintenance is an attainable goal for some farmers, the urgent demands to produce much greater amounts of food from limited land resources necessitates large increases in, not merely a maintenance of current fertility levels.

It has been generally accepted that the large increases in agricultural production necessary for SSA can only come through a much greater use of fertilizers, combined with fertilizer responsive varieties and improved soil and crop management techniques. Such improvements in SSA agriculture can also lead to a contaminant enhancement of the natural resources that agriculture depends on.

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Issue 7

The SAATS Initiative is a regional program, and will support subregional grouping and collaboration. Indicators and measures must be identified that clearly describe the impact and benefits from regional, national and institute level activities that can be integrated into the progress monitoring and impact assessment plans of the SAATS supported programs.

The initial focus of the regional strengthening activities in support of achieving program outcome 3 for national programs is on the empowerment of Africans in harmonized, regional, TDT priority-setting.

Indicators that this has happened include: 1) an established regional TDT body with predominantly African membership, 2) established criteria/voting rules in the body for selection of TDT priorities, and 3) allocation of funds based on the selected priorities. The first two indicators are yes/no and the target is an affirmative answer. The third indicator could be measured as the percentage of available funds allocated via the priority-setting mechanism. Allocation of 75 percent of the funds to selected priorities after five years is sufficient to move the TDT agenda forward, yet allows flexibility to invest in secretariat, special activities, and other areas necessary for the smooth functioning of the regional body.

The key targets to be achieved are legal incorporation; certification to receive funds; adequate representation of national interests in the organization; adequate representation of private-sector interests in the organization; endorsement by the organization of guidelines for information to be used in cross-commodity and within commodity priority setting for technical and programmatic activities, based on economic, social and technical analysis; endorsement of protocols for actually making the priority-setting decisions; protocols for determining which regional training, technical assistance, and other activities for stregthening national institutions are to be supported, and to what extent; implementation of monitoring and evaluation procedures, implementation of accounting procedures for financial management, and implementation of procedures supporting eventual impact assessment.

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Issue 8

To improve the availability of and access to technology, several fundamental strategies might be used in Africa. For example, (a) establish a self sufficient national capacity to support local development, adaptation, validation and transfer of technology; (b) import technology, local capacity focuses on adaptation, validation and transfer. The use of a particular strategy will differ, largely, from one commodity system to another. And different strategies might be used for different commodity systems in a single country. Guidance is required to assist policy makers, whether public or private, determine (i) what the most efficient strategy is fo which commodity system; (ii) what the local stream of costs would be for the different strategies; and (iii) what benefits and costs can be expected in the short and long term for these different strategies.

Each country is different and may require a somewhat different research model from others of similar size. However, each country, no matter how small needs an agricultural research capacity that allows it to (i) define the research issues, (ii) identify problems (iii) solve important problems, and (iv) provide new technologies to farmers and other users. New technologies may be borrowed from other countries and international research institutions, may be developed within the country itself, or may be gained through a combination of borrowing and national development through research. All research depends on good problem identification, problem analysis, and their use in setting research priorities. Each nation should have sufficient capacity in research to be able to identify problems and constraints and plan for their solution, either by solving them with local scientists, by borrowing technoogy from elsewhere, or by forming partnerships with scientists in other countries or in international organizations that share the same or similar problems. Such a problem identification and analysis capacity could play the roleof a kind of "agricultural health service," and can be very helpful in deciding strategies to follow in planning for national research capacity and effectiveness.

Borrowing of technology can be a rational strategy in agricultural research, and nations should examine this option closely. However, this approach will only be successful when the technology works in locations outside its domain of origin. Hence to borrow technology successfully, the borrowing nation must have the borrowed technologies under local conditions, including the screening-out of technologies with greatest potential risk for producers. Thus, countries choosing to borrow technologies should have excellent capacity to test and judge the potential for success of borrowed ideas, materials, or practices. Borrowed technology can give a powerful boost to agricultural performance, but if unsuccessful can be disastrous to producers and to the reputation of the extension service.

Finding partners elsewhere to help solve problems and develop technology is also a rational alternative for small countries with limited research capacity. Here resources from global, regional or bilateral sources can be brought in to help work on problems of mutual interest, usually on problems that are not location-specific, e.g. pest problems that cross national borders. In some cases, a small nation may decide to work mostly as the host for certain

aspects of the research, and allow scientists from elsewhere to take on all or most of the research required. In other cases, a nation may decide to be a full partner in the effort, providing scientific talent, research sites and at least partial support for the research effort. Good problem identification and a plan of action to find solutions can result from effective industry or commodity analysis, and it is in that process that the scope and scale of national research involvement can be decided.

Some problems facing African nations may be location-specific and require local solutions. Here borrowing of technology usually is more difficult, as is finding potential partners elsewhere to assist in the research. For such problems, national research capacity is essential.

Many African nations may wish to adopt a pragmatic approach to developing technologies—borrowing and validating technologies when possible, finding partners to work with in some cases, and building local capacity to handle location or culture specific problems for which partners may be difficult to find. The industry analysis approach can help in this regard, working through a stepwise identification of problems and opportunities from farmers' fields to final marketed product, and deciding on a course of action to develop or obtain the technologies needed for success. Producer involvement in various stages of technology development and transfer can be useful in determining economic viability and potential acceptance of technologies, including necessary incentives for adoption.

Local costs can vary widely, even within a specific research strategy. Clearly, borrowing technology is cheaper than inventing it. Acting as a host and providing sites for testing is cheaper than undertaking a testing and screening program.

Similarly, the benefits from overcoming a problem will depend on its importance Benefits will be largely independant of the research strategy, so long as that strategy is appropriate and successful.

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Issue 9

Commercialization of technology in Africa has been constrained by the trading infrastructure that facilitates access among technology users, the legal framework that facilitates and promotes investment in private technology transfer, the policy environment that influences the profitability of technology, and the legal framework that governs public-private sector interaction. Guidance is required to identify actions that can be incorporated into SAATS supported programs to address these issues and to encourage and facilitate commercialization of technology.

A commercialization gap frequently exists between 1) the research and development technology generation of public research organizations and 2) the decisions to invest in that technology in order to commercialize it by private firms. This commercialization gap takes several forms. These will be illustrated and analyzed from legal and policy perspectives. Actions will be suggested that can be undertaken by SAATS supported programs to close this commercialization gap.

Commercialization Gap Illustrations

The gap will be illustrated for on-farm and post-farmgate technology. The latter will be emphasized at the expense of the former due to 1) the fact it is less familiar than the former and 2) the solutions are more difficult to implement.

The farm level technology adoption (commercialization) problem unfortunately is looked upon by many as the public sector research-extension interface problem. It is frequently described as being plagued by organizational separation problems that impede communications between researchers and extension agents. Further, researchers frequently take an elitist stance which precludes full circle communications whereby extension personnel channel farmers' researchable problems to researchers. Ideally, this would complement the flow of technology from the analysts to farms via extension agents.

But this may not be the most important farm level commercialization gap. That distinction may well belong to the research-input industry interface. This is due to the fact that much farm level technology is manifest in inputs, many of them purchased. For example, improved seeds really embody a substantial amount of technology. If the seed delivery system (frequently private) cannot reproduce and make it available at the time and place when farmers need it the plant breeding program is of little avail. Clearly, procedures need to be streamlined in many cases to minimize this type of commercialization gap.

Perhaps the most conspicuous gap in commercializing new technology is in the post-farmgate areas. When new technology succeeds only in creating price depressing surpluses for farmers, this is both highly visible and highly retarding with respect to farmers willingness to adopt additional new technology in the future. Likewise, this substantially dampens their enthusiasm to support research institutions as well. In some cases market expansion has not been

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coordinated with technology-led farm commodity growth because there has been no research undertaken to develop new utilization technology. In other cases characterized by new utilization technology, the commercialization gap is due to legal or policy problems to which attention now will be turned.

Legal and Policy Problems

A policy-philosophy dilemma confronts analysts at this point. Frequently when research has been funded by public funds the philosophy is that the results must be freely shared with all. But if the technology requires substantial investments, as utilization facilities frequently do, the lack of exclusive rights to this technology may well kill any possibilities for commercialization of this technology. The solution to this dilemma, of course, is enforced patent legislation. Hence, one of the measures that should be addressed where this dimension of the commercialization gap occurs is the passing of patent laws that will meet international legal standards. The other measure that must follow is the enforcement of these patent laws. In many cases both will require specialized technical assistance.

In instances where patent protection is in place there may still be a commercialization gap. It may result from insufficient information about the new product/technology for an investor to be willing to make a decision to invest in manufacturing facilities; e.g., to manufacture sweeteners from maize based on new utilizaiton research results. This gap is frequently due to the fact that public sector researchers usually are focused on solving problems to the satisfaction of their peers. Private investors may require additional information, e.g., in the nature of a marketing or economic feasibility study, before making an affirmative decision to start producing the new product. Development oriented research administrators need to remember that as long as an affirmative decision is not made in these cases a negative one is made by implication. Hence, public sector research leaders are well advised to not only work closely with potential commercialization decision makers throughout the research process but also be willing to extend the traditional research sequence to include information generation (action research) to close the commercialization gap.

For philosophical reasons, public sector researchers in agriculture and natural resources have been inclined to maintain a distance from the private sector. Rapid economic development as a specific objective of public sector research demands that this stance be reconsidered.

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Issue 10

What can be done to improve an harmonize policies and procedures to speed up the release and exchanges of technology, especially among countries within similar agroecological zones?

Developing effective and sustainable African agricultural technology systems in the context of limited financial and human resources is a major challenge for African researchers, donors and the international research community. In many African countries, NARS have been relatively ineffective in technology development and transfer (TDT). This has been due to many factors including inadequate infrastructure and physical facilities, lack of trained manpower, poor extension services, lack of assured markets and policies that relate to pricing, and poor liaison between teaching, research and extension.

Agricultural research in Africa is conducted in fragmented geo-political settings. This poses an array of impediments to TDT. The necessary regional collaboration based on partnerships and comparative advantages for cost-effective TDT is problematic. Many countries lack the political commitment and support for agricultural research. Lack of coordination in the division of responsibilities across several ministries at national levels, linguistic and communication barriers and disparities in the abilities of NARS to be effective players in regional initiatives further imped TDT.

Many countries share a common natural resource base and/or ecological zone. Agricultural technology does not recognize national boundaries. Cross-boarder spillover effects of technology are a large component of the impact of agricultural research. The potential for spillovers is great in Africa because natural ecosystems cover many countries. However, the lack of broadly accepted strategic plans to guide eco-regional, collaborative research has limited spillover effects of technology. There has been, and continues to be, duplication of research efforts at national levels resulting in an inefficient use of scarce resources.

Eco-regionally-based research seeks to link the natural resource base to commodity production research on a regional basis. This approach focuses on the possibilities of the whole environment, not just on selected commodities. Eco-regional research emphasizes interactions among subsectors and resources (eg crops, livestock, trees and soil fertility), examines the growth of agricultural systems over time, and accounts systematically for the costs of agricultural production to natural resources and the environment.

Effective TDT requires strong linkages and interactions among producers, institutional programs, national ministries, and sub-regional and regional research programs. Communication networks are, however, poor. There is an expressed concern among African NARS directors that there is a lack of integration between their institutes and the IARCs. Although the IARCs have technologies in the pipeline, the NARS have not been involved in the adaptive research needed to move technologies to the farm. Extension models based on "Training and Visit" have been effective in some countries but there is a need for cheaper and more flexible organizational models.

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Many NARS do not have adequate funding, but money is not the only problem. There is a need for a management system that sets research priorities to achieve more effective integration between technology and the demand for technology. Current management systems tend to also be weak on monitoring, evaluating and documenting research progress.

SAATS emphasizes the utilization of existing research and development capacities to make them more productive and effective, catalytic relationships between NARS and stakeholders, and the empowerment of African decision makers to set priorities and plan for problem solution. SAATS will support policies and proceedures that enhance technology release and exchanges, especially amoung countries within similar agro-ecological zones. High priority conditions and actions necessary for the successful implementation of SAATS:

Strengthen institutional and ecoregional linkages

A willingness and ability of stakeholders to focus on partnerships and programs and TDT that are ecoregional in nature.

Work with institutions that have a positive track record and which demonstrate the prospects for being responsive and effective in the design and implementation of eco-regional research and TDT. Limited resources will not be geared towards the creation of new institutions. Support will be provided to initiatives such as:

SPAAR's Frameworks for Action (FFA) which seeks to enhance effective coordination among donors, public and private institutions, universities, IARCs and NGOs and address institutional, programming and funding constraints facing NARs.

Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) which is an umbrella organization seeking to harmonize and accelerate coordination of eco-regional research conducted by NARS, IARCs, CRSPs etc.

Commodity networks doing effective eco-regional research

Integrated research of the CRSPs

Other donor consortiums such as Club du Sahel in West Africa and SADC in Southern Africa

Support analyses of national and eco-regional comparative advantages in food technology research, linked to programs in infrastructure development and market integration

Support eco-regional centers of excellence in agricultural research.

Support regional resource and agro-ecological inventories and analyses and planning linked to TDT

Support institutions and stakeholders in identifying, analyzing and monitoring key institutional and policy conditions needed for eco-regional TDT

Develop a process for establishing intellectual property rights, licensing etc. for eco-regional and multi-center research efforts.

Improve communications

Strengthen regional information exchange centers

Support the analysis of how national and eco-regional concerns interact and ways to improve their integration and harmonization.

Convene forums for drafting and implementing cross-boarder agreements

Support electronic mail networks and other approaches that link stakeholder groups on national and eco-regional scales.

Identify and support approaches that coordinate not only national and regional research but also initiatives of NGOs, university researchers and national government policy makers.

Improve NARS sense of ownership in TDT

Allow NARS to articulate their concerns, aspirations and priorities and develop clear specifications of research agenda, courses of action and responsibilities of actors.

Support human resource development, including technical and advanced training in techniques specifically geared towards TDT on an eco-regional basis.

Empower Africans through sustained funding to define and resolve problems associated with institutional and policy conditions needed to create effective regional research efforts

Lower priority conditions and actions necessary for the successful implementation of SAATS:

Support comprehensive inventories of ongoing regional programs, reviews of lessons learned, assessments of stakeholder interest in regional programs, identification of issues needing further attention during program design and conditions that limit impact of regional programs.

Develop and implement regional policies that govern regional agricultural trade and anticipated cross-boarder shifts in land use and cropping patterns for the benefit of all states of the region. These policies need to be flexible and respond quickly to changing circumstances and new opportunities.

Understand how and why perceptions and goals of policy makers, researchers, extension

agents and producers differ and how social relations condition TDT.

Identify and remedy areas of confusion and other problems associated with multiple lines of communication.

Bibliography

Lal, R. 1994. Methods and guidelines for assessing sustainable use of soil and water resources in the tropics. SMSS Technical Monograph No. 21.

Bellows, B.C. 1994. Indicators of sustainability: A proposed protocol for the SANREM CRSP

Catterson, T. 1994. Integrating natural resource management concerns into agricultural research in SSA: A position paper

Masters and Sanders, 1994 SPAAR workshop in the Gambia, March 1994.

Proc. of Symp. on Ag Trans. in Africa, Sept. 1993 APAP II Tech. Report No. 137

Initiative for Southern Africa. Strategic Objective 3. Agriculture and Natural Resource Management. USAID Review Document. September, 1994.

Breaking the cycle of despair: Building a new foundation for food security and crisis prevention in the greater horn of Africa. USAID, October, 1994.

Strengthening African research capacity: SPAAR's perspective. Workshop on regionalization of research in West and Central Africa and CORAF general meeting. March 14-18, 1994.

Report of the panel on CGIAR commitments in West Africa. John McIntire et al. October, 1994.

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SAATS is, largely, an institutional development initiative. It is aimed at addressing the conditions unique to African technology sytems. Management responsibility (e.g., Africa Regional or Global) of the SAATS initiative must be determined. Futher, the role of REDSOs in management and monitoring must be clarified and appropriate support for these functions build into the SAATS financing plan including the suitability of existing Project and Contract instruments.

The present funding mechanism for PARTS sponsored networks is as follows: funding originates in the PARTS project in AFR/SD/PSGE. The Africa Bureau makes an OYB transfer to the Global Bureau which is responsible for contracting and management, including evaluation. The Global Bureau provides a grant to the World Bank/CGIAR secretariat. The grant stipulates specific amounts for different budget line items for eac of 7 networks, and the IARC which will be accontable for the amounts granted to each network. IARCs, and the appointed network coordinators, are responsible for detailed accounting and financial management. The CGIAR secretariat provides aggregated financial reports to the Global Bureau. The REDSOs are responsible for field monitoring and helping to provide the detailed information required in responseto the Development Fund for Africa. REDSO also facilitates relationships between the regional and bilateral programs. AFR remains responsible for demonstrating impact from its funding activity.

The SAARFA evaluation of May 1993 was critical of the funding and management system in that project which was also based on joint responsibility of AFR/ARTS/FARA, R&D/AGR/IARC, and REDSO/ESA/ANR. It suggested that the REDSOs appeared to be a desirable location for the technical management and administrative oversight of regional programs. It based this conclusion on the judgement that technical management and administrative oversight should reside in the same entity and be as close as possible to the activity. It did not actually recommend that option citing tight direct hire personnel situation and problems anticipated by some in having the REDSOs directly engaged in project management. Looking at this relationship from a slightly different angle, the PARTS evaluation of July 1994 suggests that the African Bureau should continue the use of the Global Bureau for implementation of research and analytic activities because it is an efficient and effective mechanism. It did criticize the exchange of substantive and process information between PARTS and the Global Bureau. The PARTS evaluation was also critical of the tracking, reportinga nd general accountability fo the joint responsibility system. To help the African Bureau demonstrate the impact of its funding activity, the PARTS evaluation recommends the immediate implementation of a monitoring and evaluation system and the generation of cumulative impact results every six months. With these modifications the existing joint management systems appears to provide a viable base which can be used to initiate SAATS activities.

One of the principles underlying the SAATS Initiative si the need to empower African

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institutions to make decisions and allocate resources for activities which are intended to serve their interests. There is a strongly expressed desire on the part of NARS and regional institutions to reduce the influence exercise by IARCs through control of the financial resources for regional activities. While the existing system to manage funds for regional networks established under PARTS is "effective and efficient," it will have to change to respond to this principle.

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The implementation of SAATS will involve the development of new coalitions that do not exist at present, among IARCs, NARS, Universities, NGOs, and private sector agents. Thes new coalitions will result, largely but not completely, from the consolidation of existing problems and activities. To support them will require the establishment of new governance and contract mechanisms that protect the interests of the various agents. And, that greatly improve/increase the role and responsibility of African national policy makers in providing leadership. The suitability of contract mechanisms that currently exist and are accessible through the PARTS Project to support the SAATS Initiative must be closely examined.

Over the past quarter century a significant development has been the emergence of what can be termed a global agricultural research system. The global system is not formal, no one passed legislation calling for its formation, nor did anyone appropriate funds to ensure its establishment. If any organizations can be said to have played a leading role in the global system, most informed persons would probably point to the Rockefeller and Ford Foundations, since it was their efforts in initiating the international center concept that gave the greatest boost to international collaboration in agricultural research.

The global agricultural research system consists of three main types of players—NARS of developing countries, IARCs, and advanced institutions in developed countires (DCRIs). These players interact inan variety of ways and through various mechanisms, including bilateral and multilateral agreements, memoranda of understanding, contracts, and research networks. Almost every country is involved in the global system in some way and has invested some of its own resources to participate. Before the global system began to emerge, most countries had to "go it alone" in agricultural research to solve problems and get agriculture moving. Today, almost every agricultural scientist can—if they wish—be active in the global research system, to the benefit of all.

It is within the context of the global system that coalitions to improve African agricultural research should be considered. For example, the global system provides a framework withing which global collections of crop genetic resources can be made available to any interested country, either as basic germplasm materials or as advanced lines containing many desirable traits. The global system also provides a means for training and higher education of researchers, information exchanges, formation of databases, research networks on particular problems or commodities, advice and support for improvement of NARSs, and the initiation of both formal and informal coalitions to solve common problems.

One means for coalition building centers are the establishment and operation of research networks. Networks can provide a means for NARSs to participate meaningfully in focusing research efforts to overcome major constraints. Networks have been an especially important way of developing research methodologies to improve both the effectiveness and timeliness of agricultural research. Networks also provide a framework for planning, financing and monitoring applied research on common problems facing important crops. Specialized

networks on crop or livestock commodities could provide a useful forum for carrying out industry analysis as well as planning action research to get a crop or commodity moving from production through marketing. Networks are not a panacea; an effective network needs a source of strength that will serve as a force for change. Linking a group of weak programs together without at least one strong node probably means the underlying weaknesses will continue. Some networks are more "net" than "work." Still, a sharply focused network that deals with an important problem can be an effective means of achieving productivity in research and success in application of results. Such coalitions should be sought and encouraged.

1. The overall growth rate will be the weighted sum of the growth rates in the agricultural and nonagricultural sectors, where the weights represent the sectoral shares in GDP. Based on Timmer's calculation, an agricultural growth rate of 3 1/4 % p.a. is commensurate with a nonagricultural growth rate of 4 1/4 % p.a. The aggregate growth rate is thus

$$\frac{1}{4} \times 3\frac{1}{4} + \frac{3}{4} \times 3\frac{3}{4} = 4.$$

2. There has been some confusion between the 4% target for economic growth, growth in agricultural GDP, growth in agricultural output, and growth in agricultural productivity. In the current document, every attempt has been made to specify precise targets for each of these indicators.

3. This process is distinctly different from structural transformation, which is the process of realigning government policies so that they are financially sustainable.