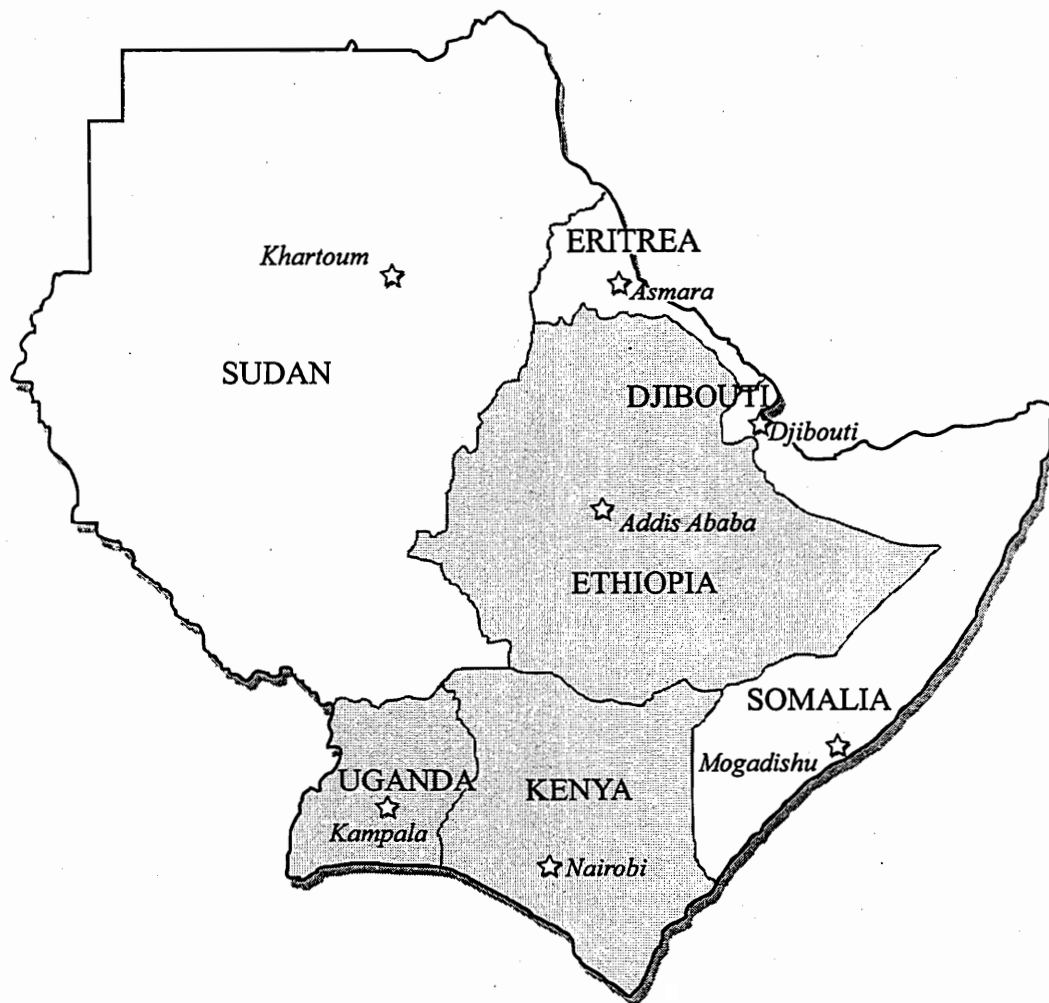


Agricultural Technology for the Semiarid African Horn



Vol. 2: Country Studies Ethiopia, Kenya, Uganda

IGAD/INTSORMIL/USAID-REDSO

December 2000

The above three are the contracting agencies. This report does not imply approval or endorsement by any of them.

IGAD (the Inter-Governmental Authority for Development)

IGAD (the Inter-Governmental Authority for Development) was created in 1986 in response to the recurrent severe droughts in the Horn of Africa. The Organization was then named The Intergovernmental Authority of Drought and Development (IGADD). Food Security and Environmental Protection were high on the regional agenda and in 1990 two regional strategy documents, one on environment and the other on food security, were developed. These regional strategies stressed the development of the region's Arid and Semiarid Lands (ASALs) which constitute more than half of the land area and are home for 20 million people, 13% of the population. The need for better inter and intra-regional networking for agricultural research was identified as a critical constraint in the food security strategy. This recommendation laid the groundwork for the creation of ASARECA in 1994 as a regional coordinating body for the commodity-based research networks of the region.

In 1996 the seven member states of IGAD (Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda) resolved to increase the level of their cooperation and expand the mandate of the Organization to include, the political and economic cooperation issues. With this new mandate came a list of 17 priority projects for the revitalized IGAD. A key to the success of this strategy has been the IGAD Secretariat's agreement to limit its role to intra-regional coordination and facilitation. The implementation of the 17 follow-on projects has been entrusted to one or more centers of excellence in the member states with technical support from one or more international centers. These projects, as earlier projects, are focused on sustainable development of the arid and semiarid lands.

The three volumes in this series are the output of one of the 17 follow-on projects. The three volume series from this project attempted to review the constraints and opportunities confronting the diffusion of new higher yielding crop technologies into the semiarid areas of the IGAD mandate area in the Horn. The first volume is a synthesis report and the following two each include three of the country reports

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Agricultural Technology for the Semiarid African Horn

IGAD

The Inter-Governmental Authority for Development

INTSORMIL

Grain Sorghum/Pearl Millet Collaborative Research Support Program

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Prologue

The Inter-Governmental Authority on Development (IGAD) includes seven countries of the Horn of Africa, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, and Uganda. The fieldwork reported in this volume is part of an IGAD project to identify drought resistant crop varieties for the semiarid zones of the Horn countries. INTSORMIL has been developing new sorghum and millet cultivars and associated technologies in Africa with collaborative research for over two decades. So INTSORMIL submitted a proposal to undertake this study in the spring of 1999. Fieldwork commenced in November 1999.

In the first phase of this project, IGAD requested a diagnostic study to include all crop technologies for the semiarid zones. IGAD defined the objectives for country analysis as: describing the cropping systems; identifying technology successes, potential successes, and constraints; analyzing the adequacy of the national, regional, and international research systems; evaluating the extension systems especially the linkages with farmers and researchers; examining seed supply and crop marketing issues; identifying the role of women with regard to the present farming system and new technology introduction; and reviewing agricultural policies.

So the first phase of this research project is a broad diagnostic study focusing on the agricultural technologies that has been successfully introduced into the Horn of Africa and the steps necessary to rapidly introduce new crop technologies in the future. As requested, there is a strong emphasis on lessons learned and what needs to be done.

The three volume series is directed to those concerned with research policy directions and with the diffusion of new technologies. The study is expected to be of interest to donors, policymakers, research administrators, researchers and those involved with moving technology onto the farm.

The study was funded from the REDSO/ESA office of USAID in Nairobi, directed by IGAD, and implemented by INTSORMIL from Lincoln, Nebraska. A core team of five professionals was contracted by INTSORMIL with IGAD concurrence. The team was composed of an economist, a maize breeder, a pathologist, a dryland agronomist, and an anthropologist. IGAD contracted two national scientists in each of the countries except for Somalia. One was contracted to review research and one for extension in each country.

This Volume 2 is the second of three Volumes in the INTSORMIL series on the identification of potential technologies for semiarid areas in the Horn countries and includes the three country studies of Ethiopia, Kenya, and Uganda.

The country studies are based upon field visits and interviews by both a core team and national consultants. These country studies also include a bibliography of the relevant literature acquired in the field and in Washington, D.C. People interviewed are indicated at the end of each country report. The core team was multi-disciplinary and multi-nationality. Individual authorship is assigned to each country report. Reports by national consultants are cited in the references and are available from the authors. Further background details on the specific objectives of the study and the names of all the personnel on the core team and the national consultants are available in Volume 1.

The core team and the national consultants are grateful for the information provided by public officials, the private sector in general, and farmers of the semiarid regions in particular. This voluntary and enthusiastic participation of people in the region made this report possible. Expert editing and word processing assistance were provided by Mary Rice, Joan Frederick, Dottie Stoner, and Kimberly Jones.

Ethiopia

Agricultural Success in the Higher-Rainfall Regions

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Acronyms

ANRS	Amhara National Regional State
Agriservice	German NGO
ARTP	Agricultural Research and Training Project
CFWCP	Community Forest and Wildlife Conservation Project
CIDA	Canadian Agency for International Development
CIMMYT	International Maize and Wheat Improvement Center
CORDEP	Community-Oriented Development Project
CRDA	Christian Relief and Development Association
DAP	Diammonium Phosphate
EARO	Ethiopian Agricultural Research Organization
FAO/WFP	Food and Agricultural Organization/World Food Program
GDP	Gross Domestic Product
IAR	Institute of Agricultural Research (Predecessor to EARO)
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IGAD	Intergovernmental Authority on Development
INTSORMIL	International Sorghum and Millet Research Program
KIT	Dutch Agency for International Development
LGP	Length of growing period
MEDOC	Ministry of Development and Overseas Cooperation
MoA	Ministry of Agriculture
NARI	National Agricultural Research Institution
NGO	Non-Governmental Organization
NSIA	National Seed Industry
PRA	Participatory Rural Appraisal Methodologies
SAT	Semiarid Tropics
SG2000	Sasakawa Global 2000
SIDA	Swedish International Development Agency
SNNPRS	Southern Nations, Nationalities and Peoples Regional State
UNECA	United Nations Economic Commission for Africa

Economic Conditions

Ethiopia has a population of 61.7 million with a growth rate of 3.3%. Per-capita income in 1997 US\$ was \$110 (World Bank, 1998, p. 190).¹ Agriculture employs 85% of the population and accounts for 49% of the gross domestic product (GDP) and 90% of the national export earnings².

Of the total land area of 112.3 million hectares, 16.4 million are considered suitable for annual and perennial cropland; 6.80 million were cultivated in 1997-98. Cereals occupied 82% and pulses 12% of the cultivated area. Of the cereals 1.75 million hectares is in teff followed by maize and sorghum (National Bank of Ethiopia, 1999, pp 6, 7).

Until the mid-'90s (from 1979-80 to 1993-94), food production (crop and animal origin) grew annually by only 0.5% (Zegeye and Habtewold, 1995). The chronic shortfalls in domestic supplies to meet minimum nutritional goals were often met through food aid and imports, but this situation perpetuates dependence on foreign aid and can strain the balance of payments.

Much of Ethiopia, especially the mountain valleys, have sufficient rainfall and good soils including a widespread occurrence of Vertisols and volcanic soils. Unfortunately, population densities are sufficiently high that Ethiopia is under continual pressure to increase agricultural productivity. Since the mid-'90s Ethiopia has become committed to a crash program of agricultural intensification. It has been amazingly successful in the prime regions in increasing yields of the principal staples. This intensification program involved the rapid introduction of improved cultivars, increased use of inorganic fertilizers, credit, and demonstration trials. In 1998-99, the value of fertilizer imports almost quadrupled from the fairly constant levels of the 1995-98 period.

The program has benefitted from several years of favorable weather. Unfortunately, the program has not been as successful in the areas of lower rainfall, the focus of this study.

In the rest of this report we will: a) contrast the successes of the '90s with the continuing drought problems at the end of the '90s; b) briefly discuss semiarid farming systems; c) review technology performance and input markets in the semiarid regions; d) briefly analyze performance of the national research, extension, and NGO activities; e) review the gender issues; f) finally, focus on the lessons learned, a technology strategy and concrete recommendations to accelerate the agricultural intensification process for the semiarid areas.

¹ Per-capita income estimated from National Bank of Ethiopia data in 1999 was 258 Birr. At 8 Birr/\$, per capita income is \$32.

² As agriculture goes, so goes the rest of the economy. In 1995-96 agriculture grew by 14.7% and the economy by 10.6%. With good weather, agricultural intensification expanded. With normal weather in 1996-97, agriculture grew by 3.4% and the economy by 5.2%. Then in 1997-98 because of bad weather, agriculture declined -10.3% and the economy grew at 0.5%. There was a recovery in 1998-99, with agriculture growing at a 4.2% rate and the economy 6.3%. (MEDOC, revised National Accounts Series, 1999). The economy grew fairly rapidly in recent years as agriculture performed moderately well or very well.

Success in the '90s in the Prime Areas

In 1993 Sasakawa Global 2000 began farm demonstrations, working within the national extension system. The initial approach of Sasakawa 2000 was to target the best agricultural areas, those with adequate rainfall. Improved cultivars of maize and wheat were identified as were improved agronomic practices, including inorganic fertilizers. Farmers were guaranteed to make at least their usual incomes on one-half hectare demonstration plots. From two regions, 167 farmers participated. With new cultivars and fertilization, maize yields averaged 5.1 mt/ha and wheat 2.8 mt/ha. In 1994, the crop coverage expanded to include sorghum and teff; 1,600 farmers participated. Maize yields averaged 5.4 mt/ha, wheat 2.8, sorghum 4.5, and teff 1.5. The media became involved in reporting these results (Quiñones, personal communication, November 1999). With former President Jimmy Carter of Global 2000, the Prime Minister visited these demonstration plots.

The Prime Minister then called a meeting in several Ministries to take over the program and expand it. He told the extension service to make a budget. The program was expanded to 35,000 participating farmers in 1995 and then 350,000 in 1996. In 1996, the program included some drought-prone regions. Fortunately 1996-97 was an excellent rainfall year. Total food production (cereals and pulses) increased to 10.4 million metric tons after having ranged from 5.4 to 7.4 million tons over the 1979 to 1994 period. The maize price collapsed from 90 to 100 Birr/quintal to 40 in one month (Quiñones, personal communication, Nov. 1999).³ This price collapse in good rainfall years when new technology is being introduced is a serious common phenomenon. The maize price collapse indicates the importance of the simultaneous consideration of market expansion as the technology is being introduced (see the later discussion of output markets).

In 1997, the number of technology packages was increased, including: (1) livestock, milk, meat, eggs, and honey; (2) high-value crops: pulses, oil crops, and vegetables; and (3) storage technologies (Table 1). Participating farmers increased to 650,000. In 1998, national resource conservation and agroforestry were added and participating farmers were over 2.9 million. In 1999, almost 4 million farmers participated. Yields were increased by two to three times for most crops for successful participating farmers (Ibrahim Mohammed, Division Director, Federal Extension Service, personal communication, Nov. 1999).

There was a substantial expansion of the extension service to support these new initiatives. Ethiopia created a revived extension service that increased in size from 4,000 extension workers in 1990 to 15,446 in April 2000 (Melaku and McMillan, 2000, p. 5). An industry of inorganic fertilizer distributors with five active firms was created in 1998 and has more entrants now. Fertilizer sales to the small-farm sector increased to almost 300,000 mt (DAP and urea) in 1999 from 90,000 in 1993 and 141,000 in 1992. The Ethiopian Seed Enterprise (a 100% government-owned firm) also evolved in its ability to provide quality seed. This company produced 14,000 mt of seed in 1994-95 and has a target of 22,000 for 1999-2000.

³ Obvious here was the importance of storage so that farmers are not obligated to sell at the post-harvest price collapse and the need to develop markets as part of the technology introduction process.

Table 1. Technologies introduced by SG2000 in 1994 and thereafter extended by the Ethiopian Extension Service.

Year	Introduction of new packages
1994	Maize, wheat, teff, and sorghum package (adequate rainfall regions)
1995	No new introductions but continued 1994 package
1996	Maize, wheat, teff, and sorghum package (semiarid regions)
1997	High-value crop package (oilseeds, pulses, vegetables) Livestock package Post-harvest technology package
1998	Agroforestry package Beekeeping package Soil and moisture conservation package
1999	No new introductions
2000	Coffee production package Irrigation package Nutrition package
<p>* The government took over and continued the SG2000 trials of 1994 and then added the new trials included in this table. The initial trials in the higher-rainfall areas have been the most successful in increasing yields, especially with maize and wheat.</p>	
<p>Source: MoA, Extension Service, Interviews, April 2000.</p>	

Since 1995 this Ethiopian experience has been an outstanding success story for rebuilding an agricultural system by: (1) developing a fertilizer-distribution industry; (2) improving the performance of its parastatal seed company; and (3) changing the orientation and increasing the size of its extension service. The packages of new cultivars with improved agronomy, especially inorganic fertilizers, were developed by the research system. In 1996, researcher salaries in the national system were almost doubled.

Two criticisms of the mid-'90s success were that (1) there was little farmer feedback and little flexibility in packages, and (2) the packages were not always tested locally nor were they always successful, especially in the semiarid regions. Dividing up the country into agroecological zones and obtaining more site-specific recommendations were two of the principal factors in the

reorganization of the Institute of Agricultural Research (IAR) into the Ethiopian Agricultural Research Organization (EARO) in May 1997 (EARO/ARTP, 1999b). This is a natural evolution of research systems to refine the technological recommendations to be more site-specific after initial gains from improved seeds and fertilizers are attained in the best agricultural regions.

Postscript on the Success: Drought of 2000

In the spring of 2000, Ethiopia was in crisis. The news reported that 7 to 8 million people⁴ were at risk of not having enough to eat until the next harvest and there were urgent appeals for food aid to the U.S. and Western Europe. If Ethiopia were so successful in developing its agriculture in the best areas, as we have reported above, what happened?

In 1998, the harvest in general was excellent and only slightly less than the record crop of 1996. Yet even with this abundant harvest, the World Food Program requested food aid for 2 million people, as this was their estimate of the number at risk (FAO/WFP Crop and Food Supply Assessment Mission to Ethiopia, Dec. 21, 1998, pp. 1, 2). In 1999, agricultural production declined slightly, 6% below that of 1998. However, the disparities between the adequate-rainfall regions and the semiarid regions increased substantially. In the surplus areas there were good crops and total production was off only 9% from the record year of 1996. Yet in the deficit regions, the declines were very serious, with a 35% decrease in Tigray, a 12% decrease in the southern region (SNNPRS — Southern Nations, Nationalities and Peoples Regional State), and 5% decrease in the Amhara region — all compared with 1998. On the national level there was a 26% decline in sorghum production and a 13% decline in maize production, although, wheat, teff, and pulse production were all higher than in 1998.

This juxtaposition of gross poverty and food deficiencies adjacent to abundance raises the chronic problem of agricultural development: increasing the food supply is not sufficient. Ethiopia could invest in transportation and communication to move food between regions, but the problem still remains of increasing the purchasing power of poor people in the food-deficit regions to buy the food. Poor people have to find ways to pay for the food. If the income-earning potential of these people collapses, then even with falling food prices, they can go hungry. The danger of relying only on food aid to resolve the problem is that by continually depressing food prices with imported food products, investments in increasing agricultural productivity are discouraged.

Another alternative for the food-deficit areas is to increase their potential to increase their own food supply. This is the alternative that we consider in the next sections of this report. Fortunately, with some strategic investments, semiarid regions have some comparative

⁴ A United Nations World Food Program report estimated that food aid will be necessary “to support 7.8 million people affected by severe food shortages resulting from droughts, water logging and other weather related hazards.” (FAO/WFP Crop and Food Supply Assessment Mission to Ethiopia, Jan. 26, 2000, pp. 1, 2).

advantages over adequate-rainfall regions. The food-deficit semiarid zones are not only a welfare problem but also a source of potential productivity and growth where more water can be made available and soil fertility improved (see Appendix I).

Farming Systems in the Semiarid regions

The semiarid areas of Ethiopia account for more than two-thirds of the total landmass of the country. According to the recent agroecological classification of the country (MoA 1998) the semiarid areas include arid (<45 days length of growing period (LGP)); dry semiarid (46-60 days LGP), moist semiarid (60-120 days LGP), and sub-moist zone (120-180 LGP) (Fig. 1). Population increases are higher in the rural areas, placing an extreme pressure on land in already established farm communities. The average population density is 35 people- km⁻² and ranges from < 10-km⁻² in Oromia zone in Bale to 250-km⁻² in Kambata and the Wolayta area.

Despite substantial variation in cropping systems across three major semiarid zones, the cereal-based mono-cropping systems are predominant across regions. Major cereals in the lowlands are sorghum, maize, and millet. Teff joins these cereals in the mid-altitudes. In the higher altitudes, the major crops are wheat, barley, finger millet, and some teff. These are mixed farming systems with small livestock being very important. Often different grain legumes are found here, again with variability by altitude and rainfall. These include common beans, peas, chickpeas, pigeon pea, and cowpeas.

The family size in the rural areas is large (with average household size of five per hectare of land) and the farms are small. The average landholding per household is generally less than a hectare in most parts of the semiarid areas. In the semiarid regions, soils are often degraded in quality and marginal in fertility. But the principal constraint is the quantity and distribution over the crop season of water, adding to the riskiness of any practices to increase land productivity. Household food insecurity is further accentuated by poor rural infrastructure and marketing services. Prices for products can vary substantially. A fundamental concern of technology development and policy support needs to be risk reduction. Hence, our emphasis is on the need to make more water available with water harvesting. This will increase the profitability and reduce the riskiness of investments to increase soil fertility.

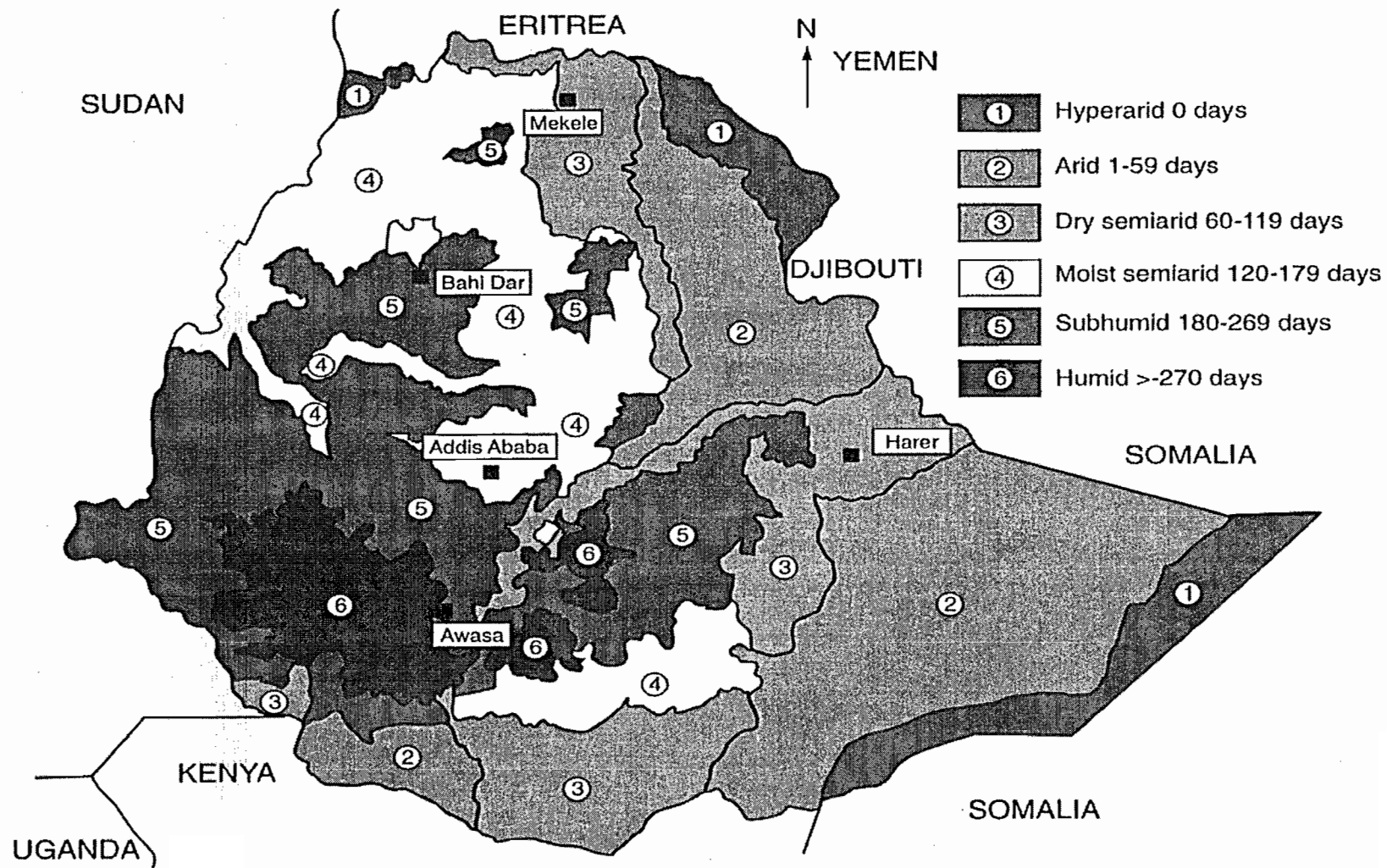


Figure 1. Growing days in Ethiopia's six zones.

Source: Adapted from EARO files.

New Sorghum Cultivars and Tied Ridges

Sorghum was included in the packages promoted by the government and Global 2000. In contrast to maize, there were few improved sorghum cultivars. Exceptions were three sorghum cultivars with *Striga* resistance introduced initially in Tigray in 1996 (SRN-39, P-94-01, and P-94-04)⁵. These early cultivars did very well in the drought year of 1997-98 and an estimated 2,000 farmers are now growing them in Tigray in the Sheraro, Adi Awala, Adi Hagerou, and Abelgela zones (Mezgabe Tsegaye, Director of Extension, Tigray, personal communication, Nov. 1999). Without fertilizer and more water, the improved shorter-season cultivars do not outyield the locals in adequate-rainfall years; however in three of the last four years, rainfall was abnormally low in the Tigrean sorghum areas. So far, this is a variety-alone success but sustained yield increases will require higher soil fertility and will necessitate more water retention.



Figure 2. Tied ridges with water between them.
Source: Farming Systems Project in Burkina Faso



Figure 3. Tied ridger attached to traditional oxen-drawn plow.
Source: EARO files

In 1996, the package extended to the semiarid regions also included tied ridges. Without the tied ridger (or other water-retention technique) fertilization is more risky and often unprofitable. The advantages of tied ridges to increase semiarid yields in heavier soils have been well documented (Appendix I). Unfortunately, the adoption rate is low because making the ridges by hand is extremely labor-intensive. An animal traction implement is necessary (Figure 2). Fortunately, animal traction is pervasive in Ethiopia.

An animal traction, tied ridger had been developed in the Nazaret experiment station (IAR) in the '90s (Figure 3). This modified version of animal-drawn tied ridges developed

⁵ These cultivars were only officially released in 1999 but had already been widely disseminated by farmers taking regional trial seed and distributing it to their neighbors (Gebisa Ejeta, personal communication, March 1999).

in the '80s in Burkina Faso in West Africa was first introduced into the Ethiopian extension program in 1996 (see Table 1) as part of the new technology introduction program aimed at the semiarid regions. Farmers complained that the implement was too heavy and awkward.⁶ Melesse Temesgen, an agricultural engineer at Nazareth, went back to work on his implement to respond to the farmer complaints. In 1999, a much lighter implement was developed and rights were bought by a local private company to start distribution. Since the local company also acquired distribution rights to several other machines, it is probably necessary for EARO to continue to promote the rapid distribution of the machine and/or to make it available to other companies.

Soil Management in the Amhara Region

Soil erosion and the lack of soil fertility are two major constraints to achieving food security in the Amhara National Regional State (ANRS). Many areas in the Amhara region have been cultivated for three thousand years. The loss of topsoil by erosion from the Blue Nile watershed in the Amhara Region is Sudan's and Egypt's gain while magnifying deficiencies of nitrogen (N) and phosphorus (P), which are the major causes of low soil fertility in the ANRS. Heavy grazing pressure on plant parts not harvested results in diminished organic matter, contributing to erosion and diminished capacity for biological nitrogen fixation.

With one of the most serious erosion problems in the world, Ethiopia loses approximately 12 tons/ha/yr, with losses exceeding 300 tons/ha/yr, or 250 mm/yr on steep slopes such as are common in the Amhara Region. Although in the Amhara Region between 1976 and 1990, 71,000 ha of soil and stone bunds, 233,000 ha of hillside terraces for afforestation, 12,000 km of checkdams in gullied lands, 390,000 ha of closed areas for natural regeneration, 448,000 ha of land planted with different tree species, and 526,425 ha of bench terrace interventions were completed, by 1990 only 30 percent of the soil bunds, 25 percent of the stone bunds, 60 percent of the hillside terraces, 22 percent of land planted in trees, and 7 percent of the reserve areas still survived (USAID, 2000 pp.7, 8). Clearly, soil and water conservation measures are urgently needed in Amhara Region, as well as elsewhere in Ethiopia.

⁶ The advantages of tied ridges are well appreciated by farmers, although the adoption rate is very slow, because it is tedious and time-consuming to make them by hand. Farmers' attitudes toward the implement introduced in 1996 were assessed. Almost all farmers responded that the implement was too heavy for oxen to pull, especially when they were weak after dry-season feed shortage, which coincides with the time of land preparation. Farmers also indicated that the implement is made of metal making it heavy and expensive. Also, working with the tied ridger required additional manpower to guide the oxen to go straight and keep the specified row spacing (Georgis, 1999, pp. 23-25). The new implement in Figure 3 was an extension of the traditional plow with a small piece of metal and would be lifted to leave the furrows closed.

For the really degraded marginal regions it is necessary to keep non-farm alternatives open:

“food security cannot be achieved by focusing only on chronically food insecure zones. The production of agricultural surpluses from high potential zones can provide low cost food to deficit areas. Success in high potential areas can reduce degradation in marginal areas by reducing production pressures on degraded and marginal land. Further, high potential areas have greater capacity to generate off-farm income for household members from low potential areas by employing labor in upstream (input provision) and downstream (agriculture product transformation) agricultural sector activities and other small businesses. On the other hand, the technology packages used in high potential zones are generally not appropriate and need to be adapted for more marginal, drought-prone areas.” (USAID, 2000 p. 6).

Input Markets

Seed Sector

One consequence of the '90s success story in the prime agricultural regions has been to adversely affect seed production for semiarid regions. In 1994 the parastatal, Ethiopian Seed Enterprise, was instructed to become more profitable. It has shifted its activities from a wide range of semiarid crops to a concentration on hybrid maize and wheat following the example of the main private seed company in Ethiopia, Pioneer. Seed production of teff was reduced from 24,000 quintals in 1994 to 2,400 in 1999. Teff is the principal staple of Ethiopia, widely preferred for injera. Seed production of the primary activities of the semiarid regions including grain legumes, sorghum, millet, and most grain legumes were largely phased out.

One consequence of Ethiopia Seed Company's phasing down of seed production for the semiarid region has been an increase in the number of community-based seed production projects. The problem with this type of local level project is quality control, especially for isolation and roguing. This type of decentralized private sector and community seed production can work with adequate technical help from EARO and the regional research technicians, who have often been hired as consultants or employees to begin the project. Over time, however, the EARO and regional research employees will need to return to their jobs, although in the initial enthusiasm period they may provide substantial technical input. NGOs often attempt to provide the technical inputs here but this requires highly trained staff and is not usually cost effective in moving beyond a pilot project. Neither NGO community seed projects nor EARO private-sector spin-offs represent a long-term solution, especially when seed demand is expanding rapidly.

What can be done to encourage the development of a private sector to service the semiarid sector? Breeders and other agricultural scientists are well-trained and often innovative and have a wide range of contacts. Incentive systems need to be set up to encourage them to be involved

in the diffusion process of new seeds and other technologies. For example, breeders could receive payments when their material is successfully diffused to farmers. This would be a strong incentive to get them to search for companies or help start small national companies. Similar operations could increase the availability of teff, sorghum cultivars, or other grain legumes. Besides unleashing their entrepreneurial ability, this financial incentive would also encourage agricultural scientists to put more effort into community-based seed programs until the demand for seed is increased sufficiently to interest the private sector.

The seed sector has made substantial progress in the higher-rainfall regions but has not serviced semiarid regions as well. Both sorghum and teff need the resumption of professional seed production. Communal seed production will not maintain quality, and continued agricultural development requires increased availability of higher quality seed of new cultivars. The grain legumes and oilseeds need to benefit not only from the evolution of the seed sector but also the growth of new markets. The real test of privatization is now to move the system beyond hybrid maize and the prime regions. This may even ultimately involve moving Ethiopian Seed Enterprise back to the development of smaller, high-risk markets, such as for pigeon pea and orphan crops (those crops in which the private-seed sector is not presently interested) until they become sufficiently profitable to be taken over by private companies.

Fertilizer Sector

One of the main successes of the '90s has been the rapid evolution from a state to a private fertilizer industry, the increasing use of fertilizers, and the phasing-out of fertilizer subsidies for both distributors and farmers. As with the seed sector, the concentration of this industry has been on the higher-rainfall regions where the hybrid maizes and, in the higher altitudes, the improved wheat cultivars have been introduced. Without water harvesting or some technique to increase water availability, fertilizer use is risky in semiarid regions.

Functioning of National and Regional Research Systems

In 1996, with the successes in the high-rainfall regions with new cultivars and fertilization, researcher salaries in IAR doubled. In 1997, IAR was restructured into EARO and the enlarged research/extension system received a \$90 million World Bank loan in 1998. Restructuring involved: (1) expanding the scope of the research system to include the agricultural universities and the regional research/extension systems in the new principal regions of the country,(2) an increased focus on regional adaptation of research in response to the problems resulting from the blanket recommendations commonly made for fertilizer and new cultivars in the rapid expansion period of the '90s (note the intensive efforts of EARO in defining agroecological zones and the proposal to construct nine regional soil laboratories),and (3) improving the research/extension/farmer linkages.

The failure by IAR and EARO to support much of the research or extension for the semiarid zones presents big opportunities for EARO presently given the interest that donors are again showing, especially the World Bank. Within EARO there has been the creation of five new semiarid centers and a central, inter-program “semiarid regions” program at the national EARO headquarters. There is also increasing funding for semiarid area components within the present centers, although the basic orientation of these programs remains strongly focused on new cultivar development rather than on water retention and soil fertility.

This program justification is often made in terms of the serious malnutrition and poverty in these semiarid areas. But the principal reason for investing in the semiarid regions is not for welfare improvement but also for the economic opportunities these zones provide when water availability and soil fertility are improved. In this case, these regions have a comparative advantage over higher-rainfall regions because of longer sunlight and less disease, as demonstrated in many regions of the world, including much of Australia, Israel, and California.

It is worthwhile to look in detail at the welfare aspect as in the Amhara regions. The Amhara National Regional State (ANRS) of Ethiopia is composed of 105 *woredas*, of which forty-eight are drought-prone and suffer from frequent food shortages. Many households in these drought-prone areas within Amhara Region can produce sufficient food to meet their food requirements for less than six months a year, and in Amhara Region, 80 percent of children suffer from stunted growth. Of the 15 million people in the Region, 89 percent live in rural, agricultural households, and cereals account for 80 percent of cultivated land and 85 percent of total crop production (USAID, 2000, p.3).

In spite of the push for decentralization of research and development in Ethiopia there is a striking contrast between the resources of the Ethiopian Agricultural Research Organization and the agricultural research organization of the National Regional States of Ethiopia. For example, Amhara Region, which includes approximately 15 million people, is served by three ANRS agricultural research stations; they are located at Adet, Sirinka and Sheno. In February, 2000, the training of the scientists at these three stations was: 2 Ph.D., 18 M.S., and 51 B.S., and 2 DVM (Doctor of Veterinary Medicine). In contrast to EARO scientists, the ANRS researchers are generally paid less. Moreover, with limited funds for operational expenses in the ANRS, the highest agricultural research funding priorities are for staff with operational expenses and capital expenditures very limited. There is little funding available to support advanced degree training of scientists within the ANRS agricultural research system (USAID 2000, p. 24, 25).

Functioning of the Federal and Regional Extension Services

The fundamental problem of the semiarid regions for the extension service has been the lack of an adequate technology package from the research establishment. We documented above that the early tied ridger had operational problems on farmers' fields. The new version appears to be very effective but production has just begun (1999) in a private company. The principal focus of research has been on new cultivars. Unfortunately, higher-yielding cultivars will not be successful on farmers' fields without complementary investments in water retention and soil fertility.

Without sufficient support from public policy for the semiarid regions, extension agencies retreat to slogans, such as the promotion of indigenous technology and the myth of local-variety superiority. These two concepts are now being heard all over the country and were frequently repeated in our field trip to Tigray. These two concepts can be summarized as the diffusion of best-farmer practices and this can be useful. However, the big gains from agricultural technology are with the application of science to agriculture, especially the rapid response to biotic constraints as they emerge, the utilization of higher input levels, and shifts to more valuable crops.

These techniques also need to be applied to semiarid areas — unless the public-policy goal is to leave farmers out there to remain in poverty until with falling birth rates and industrialization in one or two decades, they can be attracted off the farm.

As a result of its successes in the prime agricultural regions, the extension service has expanded rapidly and is justifiably proud of its achievements. The demonstration trials described earlier are tied to receiving credit and facilitating access to improved seed and inorganic fertilizers. So for the areas with sufficient rainfall, there have been substantial increases in productivity. In these areas there is good support from farmers and high morale.

The structure of the extension service includes a small, highly trained federal component with a concentration of personnel in the regions.(Tables 2 and 3). A rapid build-up of a more decentralized system then will have an increasing number of extensionists without sufficient technical training. In the search for local extension agents, who speak the local language and know the local customs, educational level requirements for the state extension service were reduced. This was a necessary innovation to create a cadre of agents able to function effectively with farmers. The problem now is to continue the education of this new personnel.

Building up the technical capacity of the local agents in the semiarid regions and elsewhere will help them successfully collaborate on introducing technological change, especially as this technical change process becomes more rapid and depends more on using new inputs (improved seed and inorganic fertilizers), water-retention techniques, and on finding new output markets. Some NGOs may be able to collaborate in this training function.

The role of women is still limited in the extension services and shows substantial regional variation. Given the importance of the nutritional deficiencies in the semiarid regions, building up the home economics section of the extension service to encourage more production of vegetable protein, gardens, food conservation, and processing needs to be a high priority. The development of this division would also be expected to encourage more participation of women in the full range of extension activities, including direct production activities.

Table 2. Number of federal and regional MoA extension staff in Ethiopia , Jan. 1999

Federal, Regional	Total	Male	%	Female	%
Regional					
Tigray	2,393	1,918	80	475	20
Afar	1,082	844	78	238	22
Amhara	10,428	8,529	82	1,897	18
Oromoia	16,672	13,590	82	3,082	18
Somali	721	588	82	133	18
Benshangui	834	626	75	208	25
SNNPRS	10,317	8,333	81	1,984	19
Gambela	790	580	73	210	27
Harari	141	94	67	47	33
Addis (city state)	445	268	60	177	40
Diradawa (city state)	191	128	67	63	33
Total Regional MoA Staff	44,014	35,498		8,514	
Federal					
Headquarters (All divisions of MoA Extension)	817	530	65	287	35
Technical Staff	189	169	89	20	11
Agriculture Extension	52	45	87	7	13
Crop Production and Protection	48	45	94	3	6
Livestock Production. and Fisheries	28	25	89	3	11
NRM	58	52	90	6	10
Women's Affairs	3	2	67	1	33
Total Federal MoA Staff	1195	868		327	

Source: MoA, Women's Affairs Department, Addis Ababa, Ethiopia, January, 1999 and MoA, Office of Personnel, Addis Ababa, April 2000 (Melaku and McMillan, 2000).

Compared with other Horn countries, the extension service is well-funded and has a solid base of qualified staff in direct contact with farmers (Table 3). Management provides bonuses to encourage good performance. Management recognizes the need for more technical training of its staff, the importance of improving the research/extension linkage, and becoming more participatory. The biggest single constraint for the semiarid agricultural sector is the need for a series of water-retention/soil-fertility alternative recommendations for the different soil types — for which it needs support from the regional research organizations and EARO.

Table 3. Number of extension agents and supervisors in direct contact with farmers

Regions	Development Agents				Supervisors			DA & Sup.	
	Male	Female	Total	Female %	Male	Female %	Total	DA+ Sup.	Sup.- DA Ratio
Tigray	721	11	732	1.5	103	--	103	835	1:7
Afar	n.a.	n.a.	51	n.a.	--	--	8	59	1:6
Amhara	2964	1025	3989	25	483	18	501	4490	1:8
Oromia	4025	724	4749	15	403	2	360	5189	1:13
Benshangul	125	32	157	20	22	--	22	179	1:7
SNNPRS	3232	795	4027	20	262	5	267	4294	1:15
Gambela	89	2	91	11	11	--	11	102	1:8
Harari	15	2	17	11	n.a.	n.a.	2	19	1:8
Dira Dowa	n.a.	n.a.	15	n.a.	4	0	4	19	1:4
Sumali	n.a.	n.a.	248	n.a.	n.a.	n.a.	n.a.	248	n.a.
Addis Ababa	5	4	9	44	2	1	3	12	1:3
Total	7151	1871	14165	—	887	29	1281	15446	1:11

Source: MoA, Extension Department, April 4, 2000 (Melaku and McMillan, 2000).

Broadening Extension Activities

NGO Involvement in Agricultural Research and Extension

Many of the constraints faced by the semiarid zones are beyond the mandate of EARO and the MoA and will require a partnership approach that links EARO's technical experts to a network of committed partners that includes the area's major institutions of higher education as well as farmer groups, NGOs, and the most relevant international and regional development networks including the CGIAR Centers, CRSPs, and the private sector.

In the short run, the NGOs are likely to be some of EARO's most committed non-governmental partners. A large number of NGOs are working in the semiarid zones and many already are in communication with EARO and even conducting farm trials (see Table 3).⁷ These NGOs want the types of technological knowledge EARO has. EARO in turn sees the NGOs as having a comparative advantage in getting technical information from and to the village.

Some NGOs have developed strong working relationships with EARO for adaptive, on-farm research, and the exchange of information. Many of these same agricultural NGOs have played an active role in the conceptualization and revision of the new "Semiarid Agricultural Research

⁷ At any point in recent time, there are between 200 and 300 registered NGOs in Ethiopia. Approximately 160 of these are registered with Christian Relief and Development Association (CRDA).

Strategic Plan” (EARO, 1999a). There is also a very active agricultural and environmental working group comprised of 15 NGOs that operates under the aegis of the NGO coordinating body, the Christian Relief and Development Association (CRDA).⁸

Between 80 and 100 of the NGOs registered with CRDA have agricultural programs. In contrast to Kenya and Uganda, where many NGOs hire their own extension workers, most NGOs in Ethiopia contract with the state extension services to provide transportation and/or “top offs” (salary supplements) to cover extra travel and living costs and job share between the MoA and the NGO.

Many of the same community-development programs rely heavily on EARO’s regional agricultural centers for seeds and technical advice. The most common pattern of obtaining information or genetic material is for an NGO office director and/or the person responsible for the agency’s agricultural programs to approach the center specialist on a particular technology. Since a great deal of this new material was still considered to be in EARO’s “phase two” of adaptive research, the NGO distributions of new material were considered to be on-farm trials.

One of the most common complaints (on both sides) is that there is no formal mechanism for the NGO to give the EARO research center any sort of structured feedback on the success/failure of particular innovations. This lack of structured feedback from the NGOs is contrasted with the formal channels of communication that are established between the regional MoA extension services and the EARO research centers.

There were, however, a number of NGOs that did manage to work in much closer collaboration with EARO. One outstanding feature of these collaborative programs has been their commitment to detailed reporting of their results in the form of reports and workshops for EARO headquarters and the regional research institutes. Especially important were Farm Africa, SOS-Sahel, and Agriservice. Activities included new varieties; new cultivation practices (bunds, tied ridging, agronomic practices); soil-fertility management, including tests of organic and inorganic fertilizer; and new methods of participatory on-farm interaction between MoA extension agents and farmers.

Factors Affecting NGO Success

Since its inception in 1974, the NGO CRDA has played a major role in facilitating the exchange of information among NGOs and between the MoA and NGOs via: (1) its monthly meetings,

⁸ CRDA is an umbrella organization for some 160 indigenous, faith-based, and international NGOs in Ethiopia. About 50% of the members are local NGOs. Since 1974, CRDA has provided an interface between its members and the government. The same organization facilitates communication between its members via monthly meetings and a series of working groups (including one on agriculture and environment) and sponsors training workshops and small-grants activities that are designed to build the technical and administrative capacity of its members. CRDA was recently selected by the Washington, DC-based Interaction Network as an example of “best practice” in NGO coordinating groups.

which tend to be well-attended by the representatives of the full membership; (2) the bi-monthly meetings of its Agriculture and Natural Resource Management working group comprised of 15 NGOs; and (3) its more specialized workshops, such as the 1996 Agricultural Extension Workshop which brought together 71 representatives from the MoA and the NGO community to discuss the government's new policy on agricultural development.

Probably the single most important factor that distinguished the NGOs that have worked most effectively with EARO was the presence of Ph.D. and M.S. level agricultural scientists on their staff. Many of these NGO staff had also worked in EARO or the MoA. The high concentration of CRDA staff (6 of approximately 30 employees) with technical agricultural training — including the Director and the head of the Monitoring division — has increased CRDA's ability to support the agriculture and NRM working group.

A second factor that has substantially enhanced the impact of NGOs on technology transfer has been EARO's recent increased collaboration with a wider range of partners (e.g., research/extension/farmer linkages) since the creation of EARO from IAR in 1997. This new collaboration has been reflected in: (1) an increased number of NGOs working with program directors of EARO to identify priority areas for collaborative research; (2) a greater number of NGOs attending EARO's strategic planning sessions (for the Soil and Water Research Program and the Arid Lands Program, for example); and (3) increased NGO participation in the formulation of the annual research plans of the regional technology centers.

The NGOs are also being invited to comment on specific policy documents, to review EARO strategy documents, and to participate in workshops, such as the National Fertilizer Workshop. Many of these invitations are made directly to prominent agricultural NGOs, such as FARM, SOS/Sahel, and Agriservice; others are made through CRDA.

A high percentage of NGOs appear to work primarily with the regional research centers because of greater ease of contact. The NGO programs that have been most effective in technology transfer have been those that have combined a commitment to regional-level collaboration (with the MoA and EARO's regional research institutes) with strong collaboration from EARO's central research programs where there is a concentration of the agency's most highly trained manpower.

In summary, the NGOs and the NGO umbrella organization, CRDA, are playing an active role in technology transfer in semiarid agriculture and their role is complementary with that of the research/extension system. To date, however, the full impact of these non-governmental investments in agricultural research, extension, and capacity building has been hampered by the lack of established communication channels between the NGOs and the central EARO program offices. While some of the most active NGOs — with high levels of technical expertise and/or professional ties to program directors in EARO — have been able to carry out this type of collaboration, they are more the exception than the rule.

Gender Issues in the Technology Development Process

Women are responsible for about 40% of all agricultural labor in the country (MoA, 1992). Hailu (1997) found that women in her study areas within the southern nations and nationalities region were responsible for 33 to 37% of the crop production and 70% of the livestock production activities. She also found that women contributed 15 to 25% of the labor in reforestation and soil conservation programs. Similar patterns were observed in the Amhara and Tigray regions (Table 4).⁹

Recent research in the Amhara Region shows evidence of women owning oxen and engaging in plowing (Frank, 1999, p. 10). The same study indicates that women who have adult sons living with them, providing them a labor source over which they have control, “are as effective at farming as men and make the same type of agricultural management decisions as male-headed households” (*ibid.*). Masefield’s (1996) research in northern Ethiopia indicated that female farmers (most with absent husbands) plowed their land during the struggle to overthrow Mengistu.

Other studies show that women in the Amhara Region who ran female-headed households were entitled to equal access to inputs from the service cooperatives. They had direct access to fertilizer and were rated as food self-sufficient (Frank 1999; see also Tiruneh et al., 1998, p. 8). Another study in the central highlands of Ethiopia (Tiruneh et al., 1999) showed that male-headed households could increase productivity by using more labor and fertilizer while female-headed households could do so by using more land and fertilizer.¹⁰

⁹ Sample surveys of husbands’ and wives’ roles in maintaining the daily living of their families were done in South Gonder, North and South Wollo, Wag Hamra of the Amhara Region, North Omo of SNNPRS, and in Eastern Tigray. They showed that 33 and 67% of the overall total labor and time inputs, such as in housework, farm, income-generating, and off-farm activities, required in maintaining the daily living of the smallholder families in the survey were covered by wives and husbands. When respondents estimated this in terms of percent of contribution in monetary value, husbands and wives averaged 42 and 58%, respectively (Hailu 1999, p.11).

¹⁰ While male-headed households had a higher gross value of output, the study suggested that the gross value of output would be 1.3% higher for the female-headed households if the average values of the inputs from the male-headed households were used.

Table 4. Percent of labor and time inputs of male and female farmers in crop and livestock production from sample surveys in three regions in Ethiopia

Agricultural Activities	Amhara				Tigray				Southern	
	N. Wollo		W. Hemra		Eastern		Southern		N. Omo	
	M	F	M	F	M	F	M	F	M	F
Crops	50	50	50	50	42	58	53	47	66	34
Livestock	48	52	55	45	23*	52	—	—	33	67

*Children or hired labor usually do herding activity.

Sources: Summarized from Women in Development Program Proposal: UNECA. Amhara National Regional State Vol IX: Eastern and Southern Tigray. Vol. IX 1997 and Vol. IX 1998; and Southern Nations Nationals and Peoples Regional State Vol. IX. 1997. Addis Ababa, Ethiopia (Hailu, 1999).

The process of formulating food security strategies¹¹ at the federal and regional levels seems to have catalyzed a renewed interest in focusing strategies to address a wider group of gender and equity concerns in agricultural research and research/extension linkages. The growing recognition of these gender issues — both as factors that affect diffusion and as factors that affect EARO's ability to fulfill its wider mandate for effective research/extension/farmer linkages — led the agency to identify "gender" as one priority issue to address in the formulation of its five-year strategy.

The Women's Affairs Office is the formal structure within the federal office of the Ministry of Agriculture that is charged with coordinating extension services for women farmers. There is also a Women's Affairs Bureau within each of the regional administrations. Most regions include representatives of the Women's Affairs Division within their zonal and, occasionally, even in their Woreda administrative units. Traditionally, the women's affairs units have had a home-economics perspective that concentrated on hygiene, cooking techniques, and family planning. In contrast to the farm-extension program, the home-extension program was staffed almost exclusively by women and worked with women in male- and female-headed households. Despite their traditional focus on "social themes," the women's affairs departments have played an important role in sensitizing and advocating more broad-based gender concerns.

¹¹ These food-security strategies typically outline a series of activities that work to: (a) increase food availability through increased agricultural production and productivity; (b) increase access to food through increased household incomes and more efficient agricultural markets; and (c) improve food utilization through better pre- and post-harvest technologies and nutritional practices. Frank (1999, pp. 2, 4) notes that the written commitment of some of the programs to working with female-headed households — in particular that of the Amhara Food Security Program — contrasts with the lack of any female representation on the program's organizing committee.

When the Amhara region closed down its home-extension program¹² in favor of a new unified family-centered approach to extension, the communication of technical messages to women broke down (UNECA, 1998, p.:15; Hailu, 1999, p. 6). The Amhara Region's home-extension program was recently reinstated and is attempting to rehire some of the home-extension workers laid off (personal communication, Alemu Bogalech, Dec. 3, 1999; Frank, 1999, p. 12).

Women at all levels need leadership training to encourage them to participate more actively in public forums (Bogalech, 1999, p. 14).¹³ Better reporting on women's activities needs to take place at both zonal and regional levels (Frank, 1999, p. 13). Urging officials at the zonal and regional level to keep information disaggregated by gender will allow trends in women's participation in agriculture to be studied and more informed policy decisions to be made (*ibid.*). Finally extension programs need to address how best to reach women with extension information and how to recruit more women to become MoA Development agents,¹⁴ and EARO researchers and technicians (*ibid.*).

The early success of the MoA and Awassa College training and research programs in attaining goals of working with about 3,000 men and women farmers in SNNPRS within its first two years of operation provides a powerful example of how quickly Ethiopia's well-developed network of regional-level extension can extend new practices.

One of the long-term impacts of the CIMMYT gender program's support for various training and research opportunities for male and female researchers within EARO in the mid -'90s was to put in place the leadership that is charged with formulating the institution's first gender strategy. This strategy was further strengthened by CIDA (Canadian Agency for International Development) and Winrock's support for EARO's first gender training workshop. In Amhara State, SIDA (Swedish International Development Agency) is helping the MoA experiment with new programs to work with women farmers.¹⁵

Despite the strong verbal commitment of most NGOs to address gender issues, a high percentage of the Ethiopian NGO-supported agricultural research and extension programs have followed the general lead of the state extension and research programs in focusing on male farmers. The same programs have been hampered by a dearth of women professional employees in general and women professional agricultural extension and research staff in particular. Reflecting broader trends, however, most NGO programs are attempting to increase their consideration of women's crop production, livestock, and food processing. Two

¹² Officials claimed that the home-extension program was ineffective and wasted resources (UNECA, 1998, p. 10).

¹³ A recent AGRIDEC (1995) study noted women's memberships nationwide were limited: in peasant associations, 12%; service cooperatives, 8%; producer cooperatives, 6%; and leadership within community institutions, virtually nil.

¹⁴ According to the 1992 report by MoA on women in agricultural extension, approximately 5% of development agents were women; at that time no single female held the position of extension agent (MoA, 1992).

¹⁵ The Swedish International Development Agency (SIDA) is addressing women's lack of experience in influencing household and community-level decision-making in its rural integrated development program in Amhara region, ensuring that women hold at least half of the decision-making positions within the project committees. Reportedly this is having a profound effect on the way in which and types of decisions communities make (personal communication, S. Nigusie, 1999; Frank, 1999, p. 16).

important examples for the dissemination of NGO “best practice” for working with women farmers include the CRDA working groups on agriculture and gender.

Lessons Learned in the Semiarid Regions

We have a nine-part explanation of what has been happening and needs to happen in Ethiopia’s semiarid areas:

- 1. Research resources for this region have been few. In the latest World Bank loan to EARO and the rest of the research establishment, increasing resources are designated for the semiarid regions with the addition of five new semiarid centers. Unfortunately, the regional station concentration was still on the development of new cultivars rather than on water retention and soil fertility.**
- 2. Clearly the chief distinguishing characteristic of semiarid regions is their lack of water. For 10 years the Agricultural Engineering Department in the Nazareth station has struggled to adapt the predominant implements used by farmers and several new animal traction implements including a seeder. A tied ridger has now been developed into a simple implement, which has been distributed to about 60 farmers. With the ridger alone, maize yields were increased by 50% and to 117% when ridging and moderate fertilization were combined (see Appendix). EARO is now entering into an agreement with a national company to produce this implement and various other simple implements. Making more water available through water-harvesting, catchment, irrigation, or a series of other techniques is the first prerequisite to improving productivity in the semiarid regions.**
- 3. When more water is available, the use of other inputs, especially fertilizers and improved cultivars, gives a higher return and reduces the riskiness of the fertilization. The fertilizer market in Ethiopia has evolved rapidly and could service the semiarid regions once there is diffusion of the water-harvesting technology. The seed market now serves the adequate-rainfall regions fairly well but there is a dependence on the national seed service, Pioneer, and community seed production programs. The Ethiopian Seed Enterprise is still a parastatal but is trying to function as a private company. Its strategy is to minimize the production of smaller-market crops while focusing on wheat and hybrid maize. Ethiopia needs to encourage the entrance of new private seed firms, both domestic and international. With a profitable, encouraging environment, domestic private firms could begin responding to smaller markets and to crops less profitable for the seed industry than hybrid maize.**
- 4. Along with the evolution of the input markets, product markets also need to evolve. One dramatic illustration of the need for concern with the product market was the collapse of the maize price with the excellent harvest of 1996 to 40 Birr/quintal from a price of 80 to 100 Birr. Despite extremely high transportation costs, Ethiopia exported maize to Kenya in 1996. There are a number of other methods to increase the profitability of farmers’ production activities. Product development through value addition, such as by producing bread, beer, or animal feed from sorghum, is one example of an important activity for concern for both**

EARO and the extension service. Similarly, storage is difficult or risky, so farmers sell quickly at the post-harvest price. It is important to identify where research could make a difference. Cereal banks, where the public sector or the village enables the farmer to avoid seasonal low prices by strategically buying and selling grains, could also stabilize incomes from cereals.

5. EARO has done impressive work in distinguishing between the many agroecological zones in the country. Soon it will have nine regional soil laboratories and they can make much more area-specific fertilizer recommendations. They need to extend this to area-specific recommendations for the combined water-retention/soil-fertility alternatives. EARO's regional emphasis and initial steps to tailor technology recommendations puts it in a leadership role in the horn countries on tailoring technology recommendations.
6. Once water is available and soil fertility is increased, new cultivars are needed to take advantage of the improved environment. Then there will be a large payoff to breeding activities of new material that can take advantage of the moderately improved agronomic environments. Farmer cultivars in semiarid zones are selected for yield stability under adverse rainfall and soil fertility conditions. New cultivars need to be selected by breeders to respond to these improved agronomic environments without lodging and to incorporate biotic resistances.

All over the world breeders collaborating with other agricultural scientists have made substantial advances in combining biotic resistances of various types with higher yielding cultivars. Ethiopia is not taking advantage of this experience by developing its ties with these networks of scientists and rapidly responding to emerging biotic constraints. Unfortunately, judging from its recommended cereal cultivars for the semiarid regions (see Appendix I), EARO is under-investing in importing improved genetic material coming out in the rest of the world to respond to emerging biotic constraints in the semiarid regions. For example, *Striga*-resistant cultivars were formally released in Ethiopia only after substantial pressure from farmers. There has been no importation of lines of sorghum tolerant of Midge despite identification of the importance of this pest in Ethiopia. EARO needs to rapidly build up its networking with other institutions concerned with semiarid technologies. The cost of bringing in new material is just the adaptation trials and having Ph.D. breeders on its staff. The regional research units need to invest much more in getting their scientists trained to the Ph.D. level.

7. Once crop yields are increased with the provision of more water and fertilizer, the crop/livestock interaction will become more important — especially the improvement of feed for the livestock. Improved forages will move up the list of research priorities for the semiarid regions.
8. One main contribution of the NGO investment in agricultural development appears to be in providing the research/extension services with additional funds and services at the farm level. The NGOs have a comparative advantage in conducting adaptive on-farm research, especially in some of the most isolated semiarid zones. But they need their technology recommendations to be oriented by EARO and the regional research organizations as in

Tigray and the Amhara regions. The NGOs need to provide feedback on farm-level technology performance to EARO and the regional research organizations.

9. EARO's efforts to develop a gender strategy that is an integral part of its more broad-based research/extension/farmer linkage package is a major innovation. The same model, if successful, will have regional significance within East Africa and the Horn since it is the first such unit to be formally created within a National Agricultural Research Institution (NARI).

A Technology Strategy

Four integrated actions need to be the focus of research and extension and public policy for the semiarid areas. There are three technology actions and governmental policy support:

1. **Water-Harvesting.** The water-harvesting technique¹⁶ will depend on the soil type with three primary differences. On soils with slow infiltration, water harvesting is essential to reduce runoff. Tied ridges, "zai", bunds, and improved land preparation are all different approaches to water retention on these soils. In sandy soils with high infiltration, actions to increase the rate of water and nutrient uptake by the plant are critical and necessary. Increases in organic matter and even inorganic fertilization (and higher density) have all been shown to slow infiltration and increase water use efficiency. On the heavy clays such as vertisols, poor drainage and sheet erosion can be serious problem. Here the water retention device often has to be knocked down in high rainfall years.
2. **Soil-Fertility Improvement.** On more sandy soils where crusting is less important but percolation into the soil can be so rapid that plants have difficulty obtaining water, a different strategy is required. In this case the key priority is to get more organic matter into the soil. ICRISAT trials at Sadore, Niger, have shown that in these sandy dune soils increasing plant density and fertilization increases water-use efficiency (for a review and references see Sanders, Shapiro, and Ramaswamy, 1996, pp. 101-106). Agro-forestry approaches to get more litter onto the soil, as well as nitrogen fixation, may be useful.

When more water is available, the returns to fertilization are increased, and risks are reduced. It is then critical to combine water-harvesting with soil-fertility amendments because of the common insufficiency of nitrogen and phosphorus in soils in semiarid regions. Usually the cheapest source per nutrient unit of these two basic macro nutrients will be with inorganic fertilizers. Generally, the supply of manure and other organic fertilizers will not be sufficient for providing the necessary N and P. More complicated alternatives — such as rotation, intercropping with a legume, and inoculation — will generally require inorganic fertilizer (P and

¹⁶ Irrigation or micro catchments are different techniques and generally do not require the simultaneous addition of the various techniques discussed here of modifications to or within the soil so as to catch or hold more water.

other nutrients) on the legume. The basic rule is to use some inorganic fertilizer and combine it with organic fertilizers and other practices to supplement the effect of the moderate levels of inorganic fertilizer. As noted previously, the objective with the inorganic fertilizer is to take care of most of the basic nutrient requirements for N and P; then complementary measures of increasing soil fertility (organic matter, cereal-grain legume rotation) can be used for other soil-fertility objectives and to reduce but not eliminate the requirements for inorganic fertilizers.

3. **Better Seed.** In this new environment with more water and higher soil fertility, the traditional varieties cannot be expected to respond very well. Traditional varieties (land races) are selected over time for yield stability under adverse conditions with inadequate water supplies and low soil fertility. New cultivars will generally respond better to the improved production conditions. New cultivars will be necessary to respond to emerging biotic constraints, such as *Striga* and midge in sorghum production. Both of these were identified as major biotic constraints in our recent trip to Tigray. There are sources of resistance to both with which breeders are working. Ethiopia just introduced two new cultivars with *Striga* resistance obtained from international collaboration (INTSORMIL and Purdue University). Texas A&M University (College Station, Texas, USA) has developed cultivars resistant to midge. It is very important for Ethiopia to be in contact with these sources of new genetic material as well as to look for higher-yielding cultivars to put in this new agronomic environment as the impacts of inadequate water and low soil fertility are being reduced.
4. **Policy Action.** Ethiopia has done much better in the '90s in focusing on agricultural development than most of the Horn countries. Demonstration trials have been undertaken all over the country all over the country. Yields of many of the basic food crops have been substantially increased. There has been a substantial expansion of production credit. Up to four million farmers in 1999 were involved in various of the demonstration-credit programs (personal communication, Quiñones, Nov. 1999). A privatized a fertilizer industry with retail outlets all over the country has been put in place in the '90s. The extension service was rapidly expanded. The salaries and the morale in the national public agricultural research system were substantially increased.¹⁷ In general, policy support to agriculture has been excellent. The government is now beginning to be concerned with alternative policies besides price support to avoid the perennial price collapses of the basic staples resulting from good weather and/or the rapid introduction of technical change.

What Needs to Be Done?

Introduce combination of technologies. Presently, in Ethiopia the principal constraint to increased crop production areas is the introduction of the combination of technologies for water availability, soil fertility, and then combine these two with new genetic material. An improved implement for tied

¹⁷ The researcher salary doubling of 1996 only included the federal researchers. The regional extension systems still do not have as much technical training, infrastructure or operational support as in the federal system. (T. Crawford, personal communication, Dec. 2000).

ridging has now been released by EARO to the private sector and there are many other methods of water-harvesting potentially available. These new technologies need area-specific adaptation; both the regional research organizations and extension services need to work on them with trials and demonstrations varying with the soils and water availability. Similar work needs to be done on the different methods of complementing the use of inorganic fertilizers. There are many other methods of water retention besides tied ridging; the technique will need to vary significantly with soil type. Area-specific experimentation will continue to be very important.

Invest in breeding activities. Substantial investment needs to be made in increasing the breeding activities. Ethiopia is not taking adequate advantage of international sources of germplasm. To do this requires good networks of international contacts and Ph.D.s among the breeders, pathologists, entomologists, and agronomists working in the commodity teams. Ethiopia needs to build up its capacity to respond to emerging biotic stresses. For example, *Striga* and midge are presently reducing yields in sorghum production in Tigray. This requires good breeding teams, probably in the regional centers, and many adaptation trials due to the substantial agroecological variation found in Ethiopia.

The extension services will have to take a large role in these adaptation trials and in demonstrations. Most demonstration trials for the principal commodities are in the better regions. Once more water and soil fertility improvements are available in semiarid regions, the stage will be set for releasing higher yielding semiarid cultivars. The myth of local-variety superiority needs to be directly confronted and the level of awareness in the extension service of the potential of importing superior plant characteristics, especially of pest resistance and higher-yielding features, is a public-education requirement in the extension service and among farmers.

Improve seed quality and supply. The production of sufficient high quality seed of new cultivars is presently the principal constraint to increasing yields in the best agricultural areas of the country (personal communication, Quiñones, Nov. 1999). This concentration of seed producers on the best-endowed zones has also had some negative effects on the semiarid regions. The public seed company has been told by the government to become profitable and has shifted most of its activities to wheat and hybrid maize, largely abandoning the semiarid crops of drought-resistant cereals and legumes (including teff, the basic Ethiopian staple). Ethiopian Seed Enterprise has emulated Pioneer Seed Company, leaving the semiarid crops to community seed production.¹⁸ Given the many problems of high-quality seed production (especially the need for isolation and roguing and, in hybrids, the nicking problem), it is unlikely that community seed production can maintain quality control over time without substantial technical inputs from professionals.

¹⁸ By imitating Pioneer, the public seed company has begun neglecting the other types of seed production normally focused on by public agencies. This is a widespread phenomenon in the Horn countries. Privatization is a fine and necessary long-run strategy for Sub-Saharan Africa. In the short run, these governments still need to service the rest of their agricultural sectors and not concentrate just on the high-rainfall, larger-farmer seed demand.

Who will pay for these professional inputs? A plan for privatization with trademarks and other market mechanisms to maintain quality control is probably necessary. The public seed sector needs to be re-engaged in the production of seed for the orphan crops, those activities that private seed companies do not presently want to get involved with. Public funds will be necessary for this activity. A requirement here is that the parastatal should have a plan to turn seed production over to the private sector once the demand growth is sufficient to interest the private sector.

Expand grain legume sector. Public-sector intervention will be necessary to expand an expansion of the grain legume sector in the semiarid areas of Ethiopia. The combined activities of introducing new production techniques with the identification of new export and/or domestic markets has been well demonstrated by the pigeon pea activities of ICRISAT in Kenya. This example of combined activities is a relevant model for Ethiopia in pigeon pea, cowpeas, and probably in other drought-resistant grain legumes. In the early stages, as marketing channels and even advance contracts are sought, the public sector will have to guarantee that there is a market — including being the buyer of last resort — to avoid a price collapse. This is necessary because substantial inputs will be required for grain legume production, including improved seeds, fertilizers, spraying for insect pests, and the control of storage pests.

Improve fertilizer industry. With the recent public sector emphasis on increasing fertilizer consumption, government officials have become entrepreneurs in the fertilizer industry. This is fine as long as a level playing field for full competition is maintained without the creation of special advantages for these new companies which result in farmers facing higher prices for fertilizers.

Developing countries need to stop referring to semiarid areas as low potential or even drought-prone and develop better terminology to indicate the agricultural potential of these regions. With the combination of increased water retention and higher soil fertility, the semiarid zones have a comparative advantages over the higher-rainfall regions, i.e., less disease incidence and more sunlight. California, Israel, and Australia did not consider their agricultural sectors as low potential and then under invest in technologies to obtain or utilize water better and then increase soil fertility. Fortunately for them, they made these technology investments before the time when people talked about low-potential or marginal regions.

Appendix I

The Agronomic Case for Technology Recommendations: Combined Water-Retention/Soil-Fertility Plus New Cultivar Strategy

Water stress is the major cause for low yields and total crop failures in Ethiopia's semiarid areas. The critical first requisite for attaining higher yields in semiarid regions is then to increase the quantity of water available. Some think only of irrigation to improve water availability. However, there are many ways of harvesting rainfall. On soils with poor infiltration water retention is made possible by improved land preparation, ridges, tied ridges, catchments, bunds, or terracing. On sandy soils, infiltration can be reduced by increasing the organic matter in and on the soil. For the heavier clay soils, such as Vertisols, drainage problems with heavy rainfall will occasionally make it necessary to knock down the water retention device. So the specific strategy for obtaining more water will then need to be adapted to the soil type and the farming system (see Box 1).

Soil fertility is the next constraint generally faced in semiarid regions after increasing the available water. The critical point to emphasize is to start with water-harvesting technologies. Why? Once more water is available, the returns to fertilization are increased and the riskiness of purchasing fertilizer is reduced. Once water availability and soil fertility are increased, the semiarid zone has an advantage over higher-rainfall zones due to the longer daylight hours and lower disease incidence. Sufficient investment in water harvesting needs to be not only a higher priority for the semiarid regions but also for the entire country.

Rather than the combination of water and soil fertility, the highest priority of the research activities in most semiarid zones has been on the development of new cultivars. *This is our principal explanation for the lack of success to date in increasing yields in semiarid regions.* Building new cultivars through interdisciplinary collaboration has been a much more exciting activity for most experiment stations than developing and introducing water-harvesting techniques and then combining these with soil-fertility amendments. Unfortunately, even though breeding activities such as the search for drought tolerance in new cultivars is a scientifically interesting activity it can only increase yields marginally¹⁹ especially where there are continuing deficits of N and P. Large yield gains result from the combination of increased water availability and fertilization as demonstrated by the following experiment station results (Tables A-1, A-2, and A-3). Once increased water and higher soil fertility are available, the new cultivars respond better to this improved agronomic environment.

Besides obtaining higher yielding characteristics breeders have developed many successful multi-disciplinary activities responding to various disease and insect problems by incorporating one

¹⁹ The basic argument is that all cultivars will require sufficient water and soil nutrients to obtain reasonable yields. Building a shorter season cultivar or developing some other drought resistance mechanism or biotic resistance does not resolve the soil fertility deficit. A higher yielding cultivar that is mining the essential soil nutrients is not a sustainable strategy.

or more resistances generally into higher yielding new cultivars.²⁰ Ethiopia and other countries need to be regularly taking advantages of these advances in new cultivars and other practices.

Box 1
Agronomic Responses to Drought

1. **Water harvesting.** There are many methods. On the clay soils or crusting soils the two primary systems are: (a) using specialized soil-management practices, such as tied ridges, “zai”, bunds, and improved land preparation, and (b) using tillage to reduce weeds and roughen the soil surface and lower runoff-inducing soil crusts.
2. **Reduce evaporation in relation to transpiration.** More marginal yield-effect practices can complement the above water-harvesting techniques. These are: (a) use of more intensive cropping systems; (b) maintaining a soil cover; (3) and adopting improved residue and tillage management practices to maintain mulches on the soil surface that will reduce evaporation.
3. **Cultivar selection for drought tolerance or drought escape.** Earliness can be selected to avoid the consequences of an early cessation of rainfall or a late planting date. Crops that have built in mechanisms to tolerate drought can be grown. Again, this is a complementary strategy to water harvesting. If either 2 or 3 here are used alone, they will have only marginal yield effects. These are the complementary practices to 1.

²⁰ Much of the Green Revolution diffusion has been built upon the new cultivar combination of a) higher yielding characteristics and b) biotic resistances. In the higher rainfall or irrigated region where the successes of the Green Revolution have been concentrated, there has always been a stress on increasing purchased input use

Table A-1. Effects of water retention methods (tied ridges) on grain yield of sorghum, mung bean, and maize in research stations of the semiarid areas of Ethiopia

Soil conservation method	Average grain yield t ha ⁻¹		
	Kobbo	Melkassa	Mean
Sorghum			
Flat planting (farmers practice)	1.6	0.8	1.2
Tied ridges planting in furrow	2.9	3.0	2.95
Mung bean			
Flat planting (farmers practice)	0.4	-	0.4
Tied ridges planting in furrow	0.7	-	0.7
Maize			
Flat planting (farmers practice)	1.2	-	1.2
Tied Ridges planting in furrow	2.7	-	2.7

Ridge height: 35 cm
 Ridge spacing: 80 cm for mung bean
 75 cm for sorghum and maize
 Ridges tied at 6 m intervals

Source: Kidane and Rezene, 1989.

Table A-2. Mean grain yield (t ha⁻¹) of five improved maize varieties grown in semiarid eastern Ethiopia under unfertilized conditions

Varieties	Grain yield t ha ⁻¹		
	Without tied ridges	With tied ridges	Increase (%)
Alemaya composite	2.8	4.8	70.9
KCC	2.6	4.3	67.5
EaH-75	2.6	3.6	38.6
Ca 5	2.3	2.9	26.4
Bukri	2.0	2.9	47.6
Mean	2.5	3.7	51.2

Source: Tamire Hawando et al., 1984.

Table A-3. Mean grain yield (t ha⁻¹) of five improved maize varieties grown in semiarid eastern Ethiopia under fertilized conditions

Varieties	Grain yield t ha ⁻¹		
	Without tied ridges	With tied ridges	Increase (%)
Alemaya composite	5.4	7.1	33
KCC	4.7	6.6	39
EaH-75	4.8	6.0	25
Ca 5	3.8	4.7	23
Bukri	3.7	4.0	9
Mean	4.5	5.7	27

Source: Tamire Hawando et al., 1984.

Soil Fertility

The soils in most of Ethiopia's semiarid areas are severely eroded and are relatively infertile leading to reduced crop yields (Figure A-1; Kidane Georgis, 1999, pp. 14, 15). Soil erosion is endemic and results in a reduced volume of soil able to retain water and nutrients. Deficiencies in N and P are especially serious and organic matter content is very low, generally less than 1%. An increase in the use of inorganic fertilizers is necessary to break out of this cycle. The inorganic fertilizers have higher concentrations of the basic plant nutrients (N, P, and K) than organic fertilizers and so their cost per nutrient unit is expected to be considerably lower than that of the organic fertilizers. Hence, the organic fertilizers are complements not substitutes for the inorganic fertilizers..

Many of these soils with low organic matter, will require a parallel increase in the use of organic fertilizers in order to hold nutrients in the soil and to increase biological activity. There are various methods for extending the supply of organic matter. Crop residues can be put in animal corrals and then the manure put in covered and watered compost heaps. These practices have been increasingly used in the Sahelian countries after the elimination of the fertilizer subsidies in the late '80s. The simplest method is just incorporating more of the plant residues into the soil once yields are increased. The constraints are on how to incorporate them and how to prevent livestock and termites from eating the residuals. The main problem of increasing organic matter is the demand by farmers for alternative uses for both crop residues and manure hence there is generally an inadequate supply of organic fertilizers for providing the basic nutrients.²¹

²¹ It is necessary to distinguish here between using the organic fertilizers for complementing inorganic fertilizers and attempting to use them to provide the basic plant nutrients. The latter is much more difficult and would be expected to only be feasible to certain types of farmers such as those producing large amounts of manure as with a concentrated poultry operation, moderate to large milking herd, or intensive beef production on a moderate to large scale.

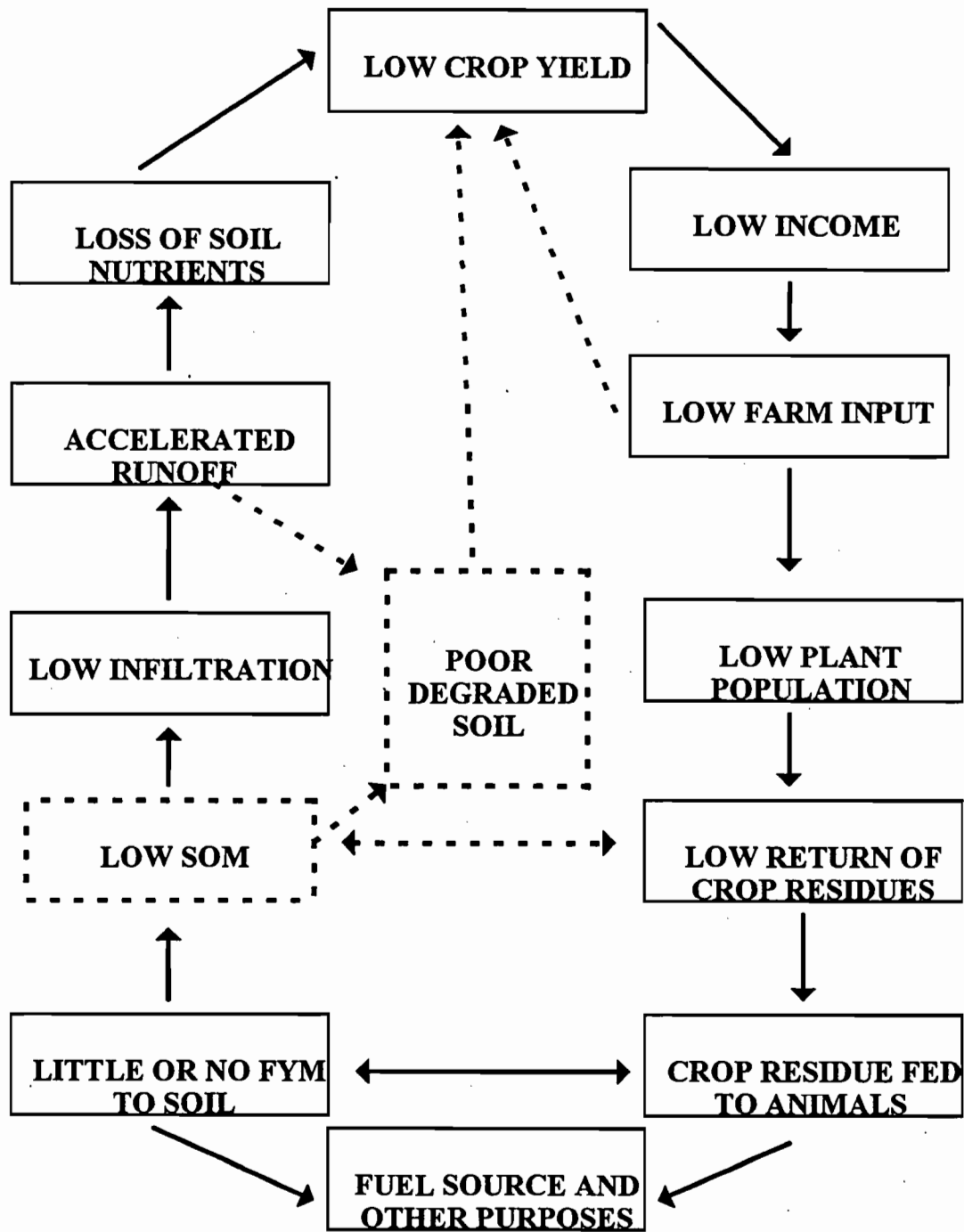


Figure A-1. The conflicts that lead to unsustainable land use for farmers in the SAT areas of Ethiopia.

Source: Kidane Georgis, 1999.

New Cultivars

The new cultivars are a very important part of the three pronged strategy (water availability-soil fertility-new cultivars). They need to combine higher yielding characteristics to respond to the improved agronomic environment and biotic resistances. The new cultivars are generally some combination of shorter, stockier materials to take higher fertilization without lodging plus consumer characteristics that are desired plus the resistances to critical insect/disease pests. For example many of the new sorghum cultivars combine: (a) shorter-season length for drought escape if the rains start late or stop early; (b) higher-yielding, i.e., better responses to inorganic fertilizers; (c) and improved consumer characteristics, such as the nutritionally improved white sorghums.

Since several new cultivars have been developed (it takes 5 to 10 years to develop a new cultivar) we provide a brief review of the presently recommended cultivars available for the semiarid region. For the principal cereals, maize and sorghum, these are extremely old cultivars. Seredo is a brown-seeded derivative of Doggett's breeding work in the '50s and '60s and Katumani maize was released in Kenya in 1968 (Table A-4). To date very little progress has taken place in the breeding of the two principal cereals (sorghum and maize) for the semiarid region of Ethiopia or to respond to emerging biotic problems.

This failure to continue active scientific work on sorghum is especially unfortunate for the white sorghums. Sorghum is widely used as a human food substituting for teff in the making of injera. These white sorghums are high nutritional quality and high yielding cultivars. This important nutritional-breeding advance continues to be constrained by the bird problem in the Rift Valley. Outside of the Rift Valley birds are not as serious a problem and can be controlled by intensive patrolling activities of children. But the Rift Valley is a major potential production area and more systematic attention to bird tolerance without using tannins would be a major innovation for the entire Horn region.

Crop failures and poor harvests due mainly to aberrant weather are common experiences in the semiarid areas of the country. The main problems in these areas are the limited amount and short duration of the rainy period and late season stress. Thus, one principal breeding strategy was screening early maturing crop species and cultivars which complete their life cycle within the period of adequate moisture. However, a detailed agro-climatic analysis carried out on some of the drought-prone areas of the country indicated the problems relative to semiarid areas are either seedling drought stress, mid-season stress, terminal stress, or a combination of any two or three of these. Therefore, it is important to consider other drought-resistant mechanisms to address the above constraints. Earliness will not always be sufficient, especially with crops such as maize and field beans that have no inherent drought resistance mechanisms but depend upon drought escape. The other problem with a short-season cultivar strategy is that it will not leave the plant in the field long enough to benefit from improved input conditions; shorter season plants yield less than traditional long-season cultivars in good rainfall years and hence would not benefit as much as longer-season cultivars when water availability is increased and soil-fertility improved.

Table A-4. Recommended crop species and varieties, actual and potential yields, and growing conditions in the semiarid areas of Ethiopia

Crop	Altitude	Rainfall	Traditional yield	Potential yield
	(m)	(mm)	t ha ⁻¹	t ha ⁻¹
Cereals				
Sorghum				
Gambella-1107	< 1600	350-700	1.2	2.5-5.0
Dinkmash	< 1600	350-700	1	3.0-5.0
Seredo	< 1600	350-700	1.0	3.0-5.0
Maize				
Katamani	< 1600	350-700	1.6	3.5-4.0
Teff				
Cross-37	1500-1800	300-500		2.8-3.0
Dz-196	1600-1800	300-700		2.5-3.0
DZ-354	1600-2000	300-700		2.5-3.0
Dz-Cr-44	1800-2400	300-700		2.5-3.0
Grain legumes				
Haricot bean				
Mexican-142	1400-2000	350-700	1.0-1.3	1.6-2.0
Awash-1	1400-2000	350-700	1.2-1.5	2.0-2.4
Roba-1	1400-2000	350-700	1.0-1.2	2.0-2.4
Mung bean				
M-76	1000-1600	300-500	-	1.5-2.0
M-1134	1000-1600	300-500	-	3.0-4.0
Cow pea				
White wonder trailing	1000-1800	300-500	-	3.0-5.0
Black-eye-bean	1000-1800	300-500	-	3.0-5.0
Oil crops				
Sesame				
T-85	< 1250	500-700	0.5	0.7-1.0
Kelafo-74	< 1250	500-700	0.3	0.6-1.2
E	< 1250	500-700	0.3	0.7-1.4
Adi	< 1250	500-700	0.4	0.7-1.7

Source: Kidane Georgis, 1999, p. 26.

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Acronyms

AISRED	African Institute for Scientific Research and Development
ASAL	Arid and Semi-arid Lands
CABIN	Capacity Building Innovation Network
CARE	Cooperative for Assistance and Relief Everywhere, Inc.
CBO	Community Based Organizations
CG	Consultative Group (IARC Centers)
CIMMYT	International Maize and Wheat Improvement Center
CRS	Catholic Relief Services
CRSP	Collaborative Research Support Program
DFID	Department for International Development
ECHO	Educational Concerns for Hunger Organization
ETC	Extract Tanning Company
FAO	Food and Agricultural Organization of the United Nations
GDP	Gross Domestic Product
GOK	Government of Kenya
GTZ	Gesellschaft für Technische Zusammenarbeit (German International Development Agency)
IARC	International Agricultural Research Centers
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
ILO	International Labor Organization
INTSORMIL	International Sorghum and Millet Collaborative Research Support Program
IRDC	International Research and Development Corporation (Canadian Development Agency)
KARI	Kenya Agricultural Research Institute
KFA	Kenya Farmers' Association
MAPF	Missionaries in Action Pentecostal Fellowship Church
MIAC	MidAmerica International Agricultural Consortium
MMDS	Mbaa Muthetheni Development Self-Help Group
MOU	Memorandum of Understanding
NARPII	National Agricultural Research Project II
NEPII	Second National Extension Project
NGO	Non-Governmental Organization
ODA	Overseas Development Administration (British Foreign-Aid Agency)
OPV	Open Pollinated Variety
REDSO/ESA	Regional Economic Development Services Office for East and Southern Africa
SECID	South-East Consortium for International Development
SIDA	Swedish International Development Agency
WAPIA	Womens' Agricultural Productivity in Africa

Economic Conditions

Kenya presently has 30.5 million people and a per-capita income of \$232/US per year. The population is growing at a 3% rate. The literacy rate is 89%, life expectancy 60 years, and 85% of the children are presently in primary school (Kirk et al., 1999, p. 3).

Agriculture contributes 33% of GDP, 70% of total employment, and it generates 60% of foreign exchange (Kirk et al., 1999, p. 3). There are three million smallholder families in Kenyan agriculture of which 80% have less than 2 ha of cropland. Smallholders are responsible for 70% of maize production, 65% of the coffee, over 50% of the tea, over 80% of milk, and over 70% of beef and minor crops (Republic of Kenya, 1995).

In the '90s the agricultural growth patterns for Kenya were reversed from the excellent progress of the two preceding decades. In the '70s and '80s agricultural GDP grew at 3.6 and 3.4% rates. By the mid '80s the public support to agriculture began declining. The degree of governmental intervention in input and product markets increased, distorting prices and economic behavior. Management quality and services declined. Real public expenditures in agriculture have been declining since 1986-87 (World Bank, 1995). In the '90s the contribution of agriculture to GDP growth has been negative, a 1.4% decline. Similarly there was a decline in the public support for research and diffusion in Kenya on the primary staple, maize. Maize yield increases fell from a 1.5% increase over the 1975-84 period to an increase of 0.3% over the 1985-91 period (Hassan and Karanja, 1997, p. 84).

The end of the '90s is an appropriate time to evaluate the successes and failures of technology introduction in the semiarid zone and to identify the key constraints and critical investments for the next decade. In this report, we

- Consider the macro-economic context and cropping systems of Kenya.
- Analyze past and present experience with successful technology introduction.
- Review the evolution of the seed market.
- Evaluate the status of the research and extension services including the NGOs.
- Review some key gender issues associated with new technologies.
- Identify lessons learned and their relevance to moving forward.

Cropping Systems in the Semiarid Regions

In Kenya, semiarid is defined by the rainfall zones between 500-750 mm¹ (Fig. 1, Table 1). Zones I to III include 15% of the crop area and zones IV and V 20%, leaving 65% defined as arid (Zones VI and VII). In the semiarid and arid zones, 9.4 million people and half of the livestock live. (Vaetozold and Schmidt, 1983).

Table 1. Major characteristics of the agroecological zones of Kenya

Zone	Altitude (m)	Rainfall (mm)	Climatic definition	Growing days	Farming system	Natural vegetation
I	1,000 - 3,000	1,000 - 2,000	High rainfall	180 - 365	Cash subsistence crops, pyrethrum, tea, coffee	Forest
II - III	1,000 - 2,000	750 - 2,000	Medium to high rainfall	110 - 180	Cash subsistence crops, wheat, barley, maize, oilseeds	Moist wood land, bush, savanna
IV - V		500 - 750	Semiarid	75 - 110	Drought-tolerant crops, maize, sorghum, millet, cowpea, pigeon pea	Dry wood land, savanna, semi-deciduous bush
VI - VII		250 - 500	Arid	< 75	Semi-desert dwarf scrub	

Note: The study is focused on Zones IV-V (semiarid). The Arid Semiarid Lands (ASAL) exhibit a wide range of diversity in topography, ecology, people, and cultures. Therefore, there are many definitions. For comparison purposes, rainfall and/or growing period have been considered.

Source: From data in Vaetozold and Schmidt, 1983 and Chabeda, 2000.

With altitude, rainfall, and soil variation, Kenya has substantial regional diversity in the crops planted and the cropping systems (Table 1). In the higher-rainfall regions of the semiarid zone, maize is the dominant cereal. Other cereals (sorghum and millet) are used as a hedge against rainfall risk and to better utilize farm-level soil variation. As rainfall declines in the semiarid regions, the role of sorghum on heavier soils and millet in sandy soils increases. Farms are

¹ In other countries, semiarid crop production is also found in regions from 350 to 500 mm rainfall. Another way to define the semiarid zone is where drought-tolerant crops are found, specifically sorghum, millet, and the drought-tolerant legumes, including cowpeas and pigeon pea.

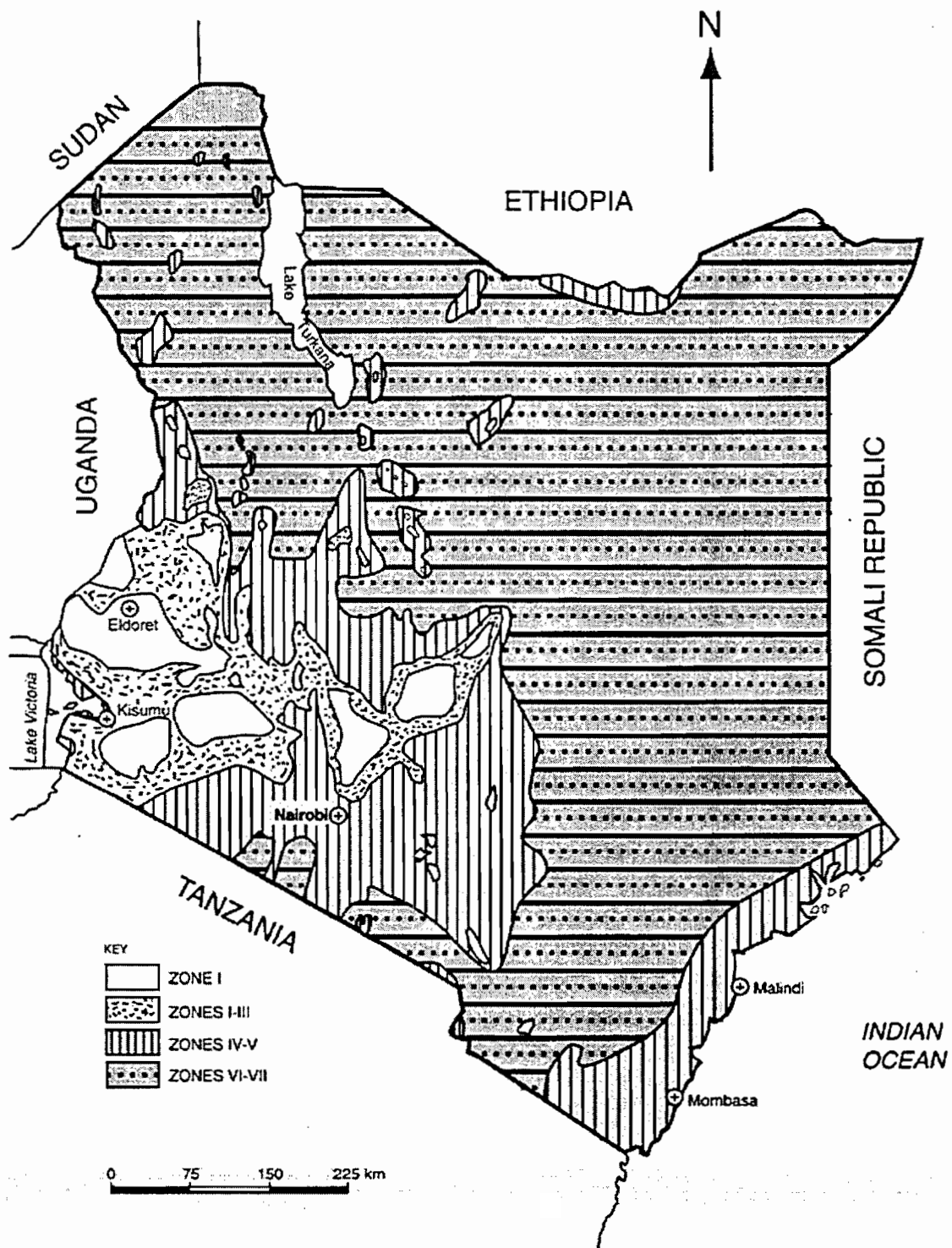


Figure 1. Agroecological zones, Kenya

Source: KARI files.

generally small, with large families and many small animals. They generally produce grain legumes, especially the more drought-tolerant cowpeas and peanuts. The semiarid crop area has declining soil fertility since the fallow system has been breaking down without being replaced by higher use of purchased inputs. As altitude increases, the crop mix changes, with wheat and barley becoming principal cereals. Grain legumes and other crops also vary substantially with altitude and rainfall.

New Technology Introduction

Water Retention

Water-retention techniques can be divided into two stages. Stage I is usually done in regions with degraded soils where there are few alternative opportunities for farmers. These Stage I techniques involve very high labor inputs undertaken outside the crop season, such as the dikes or bunds (ridges usually done on the contour to slow water run-off), the “zai” (traditional Mossi system of digging holes in the field out of season to trap water during the crop season) in West Africa and, on steeper slopes, terracing. The water retention is generally accompanied with increased use of organic fertilizers such as manure and crop residues. The effects on yields are large relatively as yields are often very low absolutely prior to the use of Stage I techniques due to the soil-fertility depletion. But the absolute yield gains are low, hence the returns to the large labor inputs are small. For example, increasing yields from 200 kg/ha to 400 kg/ha is an enormous relative increase of 100% but only a very small absolute increase of 200 kg/ha.

Stage II technologies involve improved water-retention techniques that need to be done within the crop season. Stage II techniques are generally adopted by farmers already using Stage I techniques or whose soil has not been as degraded. Hence, the opportunity costs of these farmers are not as low as for those using Stage I techniques. These Stage II operations include improved land preparation, ridging, tied ridging, and better incorporation of organic matter into the soil. Since other labor demands are high at the times required for these operations, animal traction and sometimes new implements are required. The water-retention techniques are generally combined with moderate levels of inorganic fertilizers. Yield gains are larger absolutely than with Stage I techniques but smaller relative to initial yields since these initial yields are not as low as with the depleted soils in the Stage I case.

Terracing in the Machakos region has become an internationally famous example of Stage I

(Tiffen et al., 1994).² On these hillsides there has been substantial labor investment to prevent the farms from being washed down into the valley. The terracing and vegetative barriers are combined with soil-fertility improvements, manure and crop residues. Terracing is very labor-intensive so it is employed where population pressure on the land is high and alternative opportunities for farmers are limited. The region has benefitted from good access to the Nairobi market.

Terracing is the essential first step for sloping lands. Unfortunately, neither the research and extension systems have become actively involved in moving into Stage II water retention activities. This is unfortunate because KARI has been a strong agency and has scientific capacity in these soil- fertility/water-availability techniques. This movement to Stage II techniques is the critical next step for utilizing the semiarid regions. KARI scientific leadership needs to provide support for adaptive testing of different water-harvesting/soil-fertility strategies and actively encourage their diffusion through extension and NGOs. Donor and governmental overemphasis on the prime regions (I-III, Table 1) and hybrid maize appear to be factors in this under-investment in research and diffusion of Stage II activities for the semiarid zones.

Fertilization

During the '70s and '80s Kenya increased inorganic fertilizer use on export crops (coffee, tea, sugar cane), high-value crops (horticulture, fruit), and on hybrid maize and grain legumes in the prime rainfall regions (I-III, Table 1). There was substantial donor support for increasing fertilizer use but this disappeared with structural adjustment in the '90s. Over the 1987-1991 period, donors financed 54% of imported inorganic fertilizers. Over the 1996-1999, period the donor share of financing fertilizer imports was only 9%.

Increased fertilizer imports did not develop the private fertilizer market because the subsidized imports were distributed through a parastatal, the Kenya Farmers' Association (KFA). Besides fertilizer, this organization provided extension support. With the phasing-out of donor fertilizer subsidies, the KFA has largely ceased to exist as a fertilizer distributor. It has been replaced by private importers, distributors, and stockists. A private fertilizer industry is in place, servicing cash crops, higher-rainfall regions, and irrigated areas.

With removal of subsidies and with the new marketing organization, real fertilizer costs increased

² In an attempt to institutionalize water-retention investments in 1974 the Swedish International Development Agency (SIDA) began a pilot program that evolved into the National Soil and Water Conservation Program (Republic of Kenya, 1996, p. 6) . It focused on bunds, basins, and catchments for water and reports new construction in the annual reports of the Department of Agriculture (A. Chabeda, 2000). This utilization (often) of off-season community group labor for water and erosion control is a useful first step. But there is still a concentration on Stage I water retention techniques.

substantially in the '90s. The positive factors affecting fertilizer use in the '90s are the replacement of the KFA distribution by the private sector, and the elimination of fertilizer subsidies with only a contraction but not a collapse of fertilizer use. Farmers in the prime areas have recognized the advantages of fertilizer use. Imported inorganic fertilizer imports were 314,000 metric tons in 1995-96, declining to 211,000 mt in 1997-99 (A. Chabeda, 2000).

In semiarid regions, except where some type of water harvesting is undertaken, there is much less use of inorganic fertilizers. One national maize production survey found 8 to 10% of maize farmers in semiarid areas using inorganic fertilizers (Hassan and Karanja, 1997, p. 86). For the semiarid zone, low-input strategies are frequently advocated. These strategies entail a continued search to substitute manure, other organic materials, rotation, or inter-planting of cereal/legume mixtures for inorganic fertilizers.

The traditional soil-fertility management practices include the use of crop residues, manure, and cereal/legume inter-cropping. These practices are technically sound in maintaining soil fertility, but they are quantitatively deficient. Crop residues are used for animal feed, fuel, fencing, and construction materials. Because of water stress and highly depleted soils, the biomass production is limited. Therefore, the practicality of using crop residue as a soil conditioner is almost nil. Manure is seldom available in sufficient quantities and is bulky to transport.

The option of improving soil fertility by the use of grain legumes either as a sole crop grown in rotation with cereals or intercropped, is constrained by the high harvest index of the grain legume. Relatively little organic matter and N are added to the soil since most of the above ground dry matter and almost all of the N is removed from the field in the grain. The low P content of most soils particularly in the highlands and hilly areas also inhibits successful grain legume growth and their N fixing ability. These factors limit the contribution of grain legumes to soil fertility maintenance.

Fallowing is another traditional soil-fertility maintenance practice, but this option is not practical due to continuous increase in both human and livestock population putting pressure on the land available. Okibo (1991) concluded that population pressure in a typical semiarid area in Eastern Kenya has generated a rate of depletion of soil nutrients that cannot be supplied by a conservation/biological strategy. Adequate sustainable production is possible only with inputs external to the farm, specifically mineral fertilizers. Unfortunately, organic fertilizers and rotations are not substitutes but complements to inorganic fertilizers. The best strategy for food security and sustainable agriculture is a strategy of augmenting traditional soil-enrichment practices with moderate amounts of inorganic fertilizer. Otherwise low inputs of essential mineral nutrient, especially inadequate N and P, will mean low outputs.

Therefore, the primary focus for increasing crop production in semiarid regions needs to be the combination of more water and moderate levels of inorganic fertilizers. Elsewhere we have shown the yield effects and profitability of this combined strategy in various semiarid regions (Sanders et al., 1996; Georgis, 1999; Shapiro and Sanders, 1998). The lowest-cost sources of the

critical nutrients of N and P are in a wide range of cases from inorganic fertilizers (Sanders, 1989). Organic fertilizers have a supplementary effect providing improved water and nutrient retention, improved soil structure, and other complementary effects to the inorganic fertilizers. Little of the two principal nutrients, N and P, are available from organic fertilizers unless they are applied at very high levels. The option of using organic fertilizers at high rates generally does not exist because supplies are inadequate and there are alternative uses for crop residues. With the deficits of N and P and continuing soil degradation in these semiarid regions, it will be increasingly important to use moderate levels of inorganic fertilizers combined with compost and improved rotations.

When dryland farmers take advantage of one or more of the available techniques for water harvesting, they can reduce the risks and increase the returns to fertilization. The profitability of inorganic fertilizers for farmers will then depend upon their degree of market access, which will reduce the cost of inputs and increase their product prices.

To accelerate fertilizer use in semiarid regions, the combined activities of the research and extension systems in regional adaptive trials³ of various types of water harvesting and moderate use of inorganic fertilization are essential. These combined effects need to be evaluated and economic analysis undertaken for the range of relevant prices as well as simulation for the different possible states-of-nature.

As the economy resolves some of the problems of governmental failure (undue extension into the productive activities of the economy and interference with the price system) market failure problems will again become important. For example, the private sector (input suppliers, marketing agents, truckers) tends to be most interested in larger farmers and higher-rainfall regions. This orientation to larger farmers is natural; it saves information and distribution costs for private firms. Nevertheless, developments in the private sector reducing transactions, information, and transportation costs — especially in the fertilizer, seed, and product markets — will reduce the costs of inputs and increase the profitability of more intensive production techniques in semiarid regions and for small farmers. Therefore, it is important that privatization of the economy continues even though its primary, initial beneficiaries will be the regions and the farmers with more resources. Other incentives and other policy measures to encourage the private sector to become involved outside the prime regions and programs to restore some comparative advantage to small farmers, such as cooperatives, will also be important to overcome this market failure.

³ A principal characteristic of Kenyan agriculture is a wide range of agricultural conditions because of rainfall, soil, and altitude differences. Hence, a central emphasis of all technology development has to be on regional adaptation of agronomic practices and addition of new cultivars to this improved agronomic environment. In 1994 the German International Development Agency (GTZ) began a collaborative program to move away from blanket or national fertilizer recommendations to region-specific ones (Republic of Kenya, 1999, p. 12). The construction of regional soil testing laboratories was an important component of this activity. Insufficient emphasis has been put on the necessity for the combination of the water harvesting and the soil-fertility increasing techniques.

New Cereal Cultivars in Semiarid Regions: Maize and/or Sorghum

Maize is the principal staple and the predominant food crop with approximately 1.5 million ha of production annually over the period 1994-98. Over this same period the next two cereals, wheat and sorghum, averaged annual areas of 150,000 ha and 142,000 ha, respectively (Crop Production Statistics, 1994-1998).

Successes in maize technology introduction have been very impressive. From 1965-80 maize national yields were doubled, the area tripled, and production increased fivefold (Hassan and Karanja, 1997, p. 90). These gains were based on new cultivars, principally hybrids, and higher levels of inorganic fertilizers. Productivity gains were concentrated in the higher-rainfall regions initially among larger farmers but reaching smallholders; new variety use became pervasive but with lower inorganic fertilizer use among small farmers (Hassan and Karanja, 1997, pp. 82-86).

There also have been successes with the introduction of open-pollinated varieties of maize for the semiarid regions. Katumani Composites A and B were introduced in 1966 and 1968 and Dryland Composite I in 1989. In a survey of maize producers in the semiarid zone, 57% utilized improved cultivars in 1985-1991 (Hassan and Karanja, 1997, p. 84). Of the maize producers sampled, inorganic fertilizer use was much lower than the adoption of improved varieties with fertilizer being used on only 11% of the farms.

With an excessive research focus on maize and continuing migration of smallholders from the higher rainfall highland maize is being pushed into marginal rainfall regions, where it is an increasingly risky activity. Most of Kenya government and NGO cereal crop research and development activities have been concentrated on maize. As population pressure in the highlands has resulted in increasing rural-rural migration into the lowlands, migrants have often brought their staple crops, maize and common beans - *Phaseolus vulgaris*, into the more marginal rainfall regions. The rapid push of maize into semiarid regions as a substitute for sorghum has been a widespread phenomenon of the last 30 years, accompanying the rapid increase in sales of improved maize seed (Hassan and Karanja, 1997, p. 88)

However, maize and field beans are much more susceptible to drought and low soil fertility than are the indigenous crops of the semiarid zone — sorghum, millet, pigeon pea, and cowpeas. Maize has not been that successful in semiarid areas; farmers there talk about losing their maize in 4 of 10 years and even as high as 7 in 10. In the normal adjustment process when yields collapse in areas of inadequate moisture and soil fertility, maize farmers have to adjust. However, if the collapse of maize yields is accompanied by increased food aid from NGOs, there is little pressure on farmers to adjust by growing crops, that are less risky in irregular, low-rainfall regions. In economics this is called moral hazard, where individual entrepreneurs are not pushed by market signals to make socially optimum decisions but are encouraged to make risky decisions because others — often the public sector, but here the suppliers of food aid — cover the risk.

Breeding programs have responded with shorter-season maizes but drought escape does not help when the rains are irregular during the season instead of starting late or ending early. Moreover, shorter season cultivars have a disadvantage when rainfall is normal or good. Shorter season cultivars have reduced the potential to respond to inputs, especially inorganic fertilizers and increased water availability.

CIMMYT has been working with more basic characteristics of the maize plant, attempting to develop drought tolerance by shortening the silking-anthesis interval. This technique has demonstrated higher yields of maize under water stress. However, there is still a fundamental question for the semiarid regions: Whether it is more feasible to change the maize plant to be more tolerant of drought stress or to develop markets for sorghum and millet plus reducing the processing and preparation requirements for women?

Reasons for the substitution of sorghum with maize are more complicated than just the food preferences of migrants reinforced by relief agencies and the much higher previous research investments in maize among the cereals. Other factors are: (1) serious production constraints in sorghum; (2) greater market opportunities for maize; (3) advantages to women in processing and cooking of maize; (4) incentives from public policies; and (5) providing a critical food source by being available in the hungry period before the other cereals are harvested (J. Lynam, Rockefeller Foundation, personal conversation, Nov. 1999; also Eliud Omolo, personal conversation, Nov. 2000).

Most serious of the sorghum production problems is the bird problem, especially in the Rift Valley, the probable center of origin of the Quelea bird. Farmers are still purchasing the descendants of brown-seeded sorghum cultivars. These cultivars are adaptations of the brown-seeded sorghums first developed in Uganda for bird resistance by Hugh Doggett in the '50s and '60s.⁴ Kenya Seed Company lists Seredo and Serena as two of the four improved cultivars of sorghum sold presently.

The main innovations in sorghum breeding have been increased yields, white-seeded cultivars and earliness. The white seeds improve consumer quality and the earliness gives drought escape. All three characteristics increase their attractiveness to birds. Outside the Rift Valley, the bird problem is less serious and there is some control from devices, including the strategic use of small children for this activity⁵ and wide-scale planting of sorghum maturing at the same time. There are several white sorghums on the market (sold by seed producers) including IS 67 and KARI/Mtama 1. Mr. M'Ragwa, promoter of the latter sorghum and responsible for some of the

⁴ The brown-seeded cultivars of sorghum do not have bird resistance, just non-preference. For the Rift Valley there is the possibility of looking for other bird-resistance mechanisms besides the tannins associated with brown seed color. Tannins create digestibility problems for both birds and humans.

⁵ As farmers incomes increase, they are expected to become concerned with the opportunity costs of their children being out of school.

seed production activities for KARI,⁶ claims that there is now excess demand for the high-quality white sorghums and that he often buys sorghum from other countries to respond to the higher prices from this increasing demand. High-quality white sorghums make excellent flour and Kenya has been able to produce only half, 300,000 metric tons, of its 600,000 metric-ton annual demand for wheat, in recent years (Watson and Mwangi, 1999).

Another important component of past demand shifts to maize is the greater ease of processing and preparation. With the white sorghums, these advantages are disappearing; these white sorghums are high quality human foods. Several processing techniques from other cereals can be applied, such as parboiling so that sorghum can be cooked like rice. These time saving techniques for processing and preparation can become more widely available to women with private sector activities as is occurring with millet in Senegal and starting in Kenya.

Finally, with the improvements of the agronomic environment with more water and inorganic fertilizers, improved cultivars of cereals and grain legumes can be introduced. Breeding programs for both maize and sorghum are not adequately responding to the potential of these new environments. In 1997, Katumani Composite B (released in 1968) was found on 5.3% of the Kenyan maize area, whereas the only recent innovation for the semiarid zone, Dryland Composite I (released in 1989) occupied only 0.2% of the maize area in 1997 (Hassan and Karanja, 1997, p. 83). Since responses require human-capital formation in the agricultural sciences, much of which has already been done in KARI, plus the very low-cost connection to international networks, this failure to continue to invest in semiarid technologies seems especially unfortunate. Once agronomic improvements are made (more water and increased soil fertility), there is substantial potential to increase yields in semiarid regions.

Grain Legumes and Market Expansion: The Pigeon Pea Case

Besides shorter-season maize and sorghum, grain legumes are a prime option for expansion in the semiarid regions when market conditions are favorable. For decades, pigeon pea has been hailed as a wonder crop, a perennial legume that can produce much-needed protein on poor soils while fixing nitrogen and taking up nutrients from the subsoil. The legume has been vulnerable to devastating diseases, such as *Fusarium wilt* and *Cercosporam leafspot*. More recently, improved early cultivars and the opportunity to produce pigeon pea throughout the year have opened up new market opportunities, including the export of fresh peas to Asian niche markets in the United Kingdom and dry grain to India where supplies often fail. Plant-breeding research has also incorporated other market characteristics, such as preferred grain size and color in addition to high

⁶ In the late '70s in a FAO (Food and Agricultural Organization of the United Nations)-supported program, Pinto and Whiteman selected a white sorghum from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) material in Kenya trials. This material, named KARI/Mtama 356, went into pre-release in 1978 and 1979 and later became KARI Mtama I (E. Omolo, Kenyan maize breeder, from information in KARI files).

yields, into an early maturing pigeon pea variety. The dual-purpose crop appears to be especially popular among women. The fresh green pigeon pea is less perishable than the other vegetables they grow. Even if a buyer for the green pods cannot be found, the crop can be left to mature and be harvested later as grain.

Since 1995, NGOs collaborating with ICRISAT collaboration have conducted on-farm trials of these pigeon peas with several thousand farmers, with the number of female participants between 60 and 70% (CRS, personal communication, November 1999; ICRISAT 1998, 1999a,b). New varieties of pigeon pea widely adopted by female agriculturalists in the Makindu region (near the Kiboko Research Station under ICRISAT supervision) are successfully being marketed through small family firms, such as the Makindu growers for whom they produce the crop under contract. Family members load the producers' cartons of fresh pods into pickup trucks and then drive them to Nairobi where the crop is put onto a plane bound for London. By far the most successful evidence of adoption was a highly innovative attempt to link local producers with large-scale exporters of agricultural produce, specifically the Fresh Produce Exporters Association of Kenya and Everest Enterprises Ltd., an established exporter of horticultural produce. Everest Enterprises signed marketing contracts with some of the established women's groups in the different districts that had previously worked with ICRISAT researchers. The entire production was harvested and delivered to Everest Enterprises.

Even though the market is still small, there appears to be scope for expansion of these export sales. The annual growth rate of pigeon pea production was 4.7% per year in Kenya (Table 2). In 1995-1996, India imported 82,000 tons. In 1996, this rose to 132,000 tons with estimates for the 1998-1999 season as high as 200,000 metric tons (Jones et al., 1999).

Table 2. Average production of pigeon pea in Kenya, 1980-82 to 1996-97

Production	mt
Production average, 1980-82	28,845
Production average, 1995-97	44,874
	ha
Area average, 1980-82	66,337
Area average, 1996-97	147,510
Annual growth rate in production, 1980-97	4.7%

Source: Jones et al., 1999

In the absence of these brokered overseas marketing arrangements, prices for the new varieties on the local markets appear to be less than prices paid for traditional varieties (ICRISAT, 1999). The new short-season varieties will require some modifications in the traditional farming systems. The long-season pigeon pea is grown intercropped with maize in the bi-

modal rainfall regions of Kenya. The maize is harvested in the first season, which allows the pigeon peas to further develop and be harvested in the second season. Short-season pigeon pea needs to be mono-cropped and would require spraying to control insects.

NGO officials involved with the trials confirmed the view of ICRISAT officials that one of the most important immediate constraints to increased production of pigeon peas is the shortage of seed and lack of commercial incentives for private seed companies to invest in developing quality seed. One option is for the marketing companies to do seed production.⁷

Evolution of the National Seed Market

In the process of African development, governments have often attempted to achieve welfare objectives by setting up centralized, state-controlled organizations. These organizations have become expensive with large bureaucracies, have reduced the incentives for private entrepreneurs, and have stifled the creative forces of competition. Most development programs are increasingly tying their activities to the further evolution of the private sector or privatization.

Historically, Kenya Seed Company has been a strong agency, as demonstrated by the successful diffusion of improved maize cultivars especially hybrids for the higher-rainfall regions (Hassan and Karanja, 1997, p. 88). A number of open pollinated varieties, including Katumani and Dryland Composite, have also been successfully produced and distributed by the Kenya Seed Company. Up through 1992, KARI and the extension service were providing new cultivars and demonstrations.

The Kenya Seed Company concentrated on marketing, promotion, and distribution of new cultivars. The new cultivars were not sold individually but as a package with fertilizer and pesticides. With decline of donor support to the extension and research services, especially after 1992, the Kenya Seed Company began its own research division. Meanwhile, the extension service has curtailed its promotion and demonstration activities, further increasing these costs for Kenya Seed Company.

Kenya Seed Company was 51% owned by the public sector but divestiture of the public-sector share is now taking place. The advantage of a public agency is that it has a mandate to be concerned with social welfare as well as with profitability issues. As the seed sector privatizes, seed production and distribution ultimately will increase efficiency. Seed-quality control will evolve as cultivar names become associated with specific companies. The problem is how to

⁷ Jones et al., (1999, p. 12) discuss the serious problems of encouraging private investment in the development of seeds for minor crops, such as pigeon pea.

insure that small farmers and the semiarid region benefit from the privatization of the seed and fertilizer markets.

Pioneer and Monsanto are entering the seed industry and there are new national seed companies, such as Western Seed Company. The first two are primarily evaluating their participation in the Kenya market beginning with hybrid maize production for the medium- and high-potential markets. Cargill preceded Monsanto and tried unsuccessfully for four years to obtain a seed-merchant's license. Monsanto took over the Cargill operation and applied for a license, paying the fee of 75,000 Kenya schillings (\$1,000) in December 1998. To date it has heard nothing from the government. Nevertheless, Monsanto is in the pre-release stage with two maize hybrids. This means that the company can sell 5 metric tons (first year), 25 mt (second year), and 50 mt (third year). One hybrid, CG 4141 (120-140 days, earlier than 511), is now being released. Further advances in earliness would also result in cultivars of interest in the semiarid zone, taking advantage of hybrid vigor. The two international seed companies expressed interest in semiarid regions if more water were available.⁸

In contrast, Pioneer took on a Kenyan partner (Fresco), which already had a license. Pioneer has been importing maize hybrid seed from Ethiopia and Zimbabwe for two years. In the second year of sales, the seed imported from Ethiopia sat in Mombassa because floods cut off the roads. Hence, germination rates were very low and Pioneer seed was discredited.

Some requirements to increase the capacity of the seed industry to respond to the needs⁹ of farmers in the semiarid sector are: increase incentives for entrepreneurs to engage in small niche markets to satisfy emerging domestic or international markets, such as that for pigeon pea; breeders' rights, with a percentage for the scientist and not just for the research agency, would encourage entrepreneurial activity from breeders and other agricultural scientists; public funding, as to the Kenya Seed Company, for some of the dryland orphan crops until the private sector becomes interested; well managed, scientifically based community seed production with NGOs for OPVs and other orphan crops as a temporary measure with a plan for turning over activities to the private sector.

⁸ With the addition of more water, as with water-retention techniques and higher soil fertility in the drylands, there will often be incentives to shift to higher-value products, such as horticultural crops, grain legumes for export, and maize in place of sorghum.

⁹ There are crops with a public good component, such as the dryland cereals, on which the nutritional welfare of many rural poor people depend. A public good provides benefits to not only the individuals using the services, in this case individuals improving their nutrition, but also other members of the society. There are many disadvantages to a society from malnutrition: especially the deterioration of human capital with increased incidence then expected of unemployment, crime, and various types of welfare payments.

Functioning of the Research System

Based upon its broad regional coverage, its development of scientific human capital and physical infrastructure, and its successful diffusion of technologies into the higher rainfall regions, KARI has been an impressive success story. KARI has 15 national stations, 6 regional stations, and 10 research sub-stations all manned with multi-disciplinary teams. In 1997 there were 4,964 employees with 464 research scientists, 42 top managers, and 1,521 administrative support staff. In 1989 employment was 6,200, so there has been a 20% decline in the last eight years as funding levels have been cut back. Nevertheless, the scientific capacity of the staff has increased. In 1997 there were 103 Ph.D.s as compared with 16 in 1986 and 287 M. S. s as compared with 215 in 1986 (Wakindiki, 2000).

Technology diffusion successes associated with KARI have been impressive in hybrid maize, wheat, horticultural crops and fruits, cut flowers, fertilization, and some intensive livestock operation, such as zero grazing dairy (Waithaka and Cusack, 1999). To date these successes have been concentrated in higher-rainfall zones or with irrigation and are principally produced by larger farmers. Success in the semiarid zone has been predominately with maize. There a sample of maize producers indicated that 57% are using improved cultivars and 11% fertilizer (Hassan and Karanja, 1997).

KARI has not kept up the momentum of new maize cultivar production for the semiarid zone. Maize technology introduction for semiarid regions effectively ceased with the introduction of Katumani Composite in 1968. The pace of hybrid maize introduction also slowed but new cultivar release continued as the higher-rainfall region was the focus of KARI and national extension activities.¹⁰

Nor have the breeders in KARI done better with sorghum. There have been no advances of sorghum breeders from the brown-seeded derivatives to avoid devastation from the bird problem. There is much more now known about the nutritional problems to humans and animals from the tannins. But the breeding work is still built on the concepts of Doggett from the '50 and '60s. The big initiative of sorghum breeders of an early white with much better nutritional characteristics, KARI Mtama 1, was first provided to farmers in eastern Kenya in 1991 but not officially released until 1998. Adoption rates are still reported as very low.¹¹

¹⁰ High-altitude maize hybrids are concentrated in the 1,800 to 2,200 meter range.

¹¹ In impact studies undertaken in the '90s, some limited diffusion of KARI/Mtama 1 plus Seredo and Serena was reported but no seed production or sales data were available (Waithaka et al., 1999; SECID, 1999, p. 55). Note that the white-seeded nature of KARI/Mtama 1 is very important for human nutrition and opens up markets for the sorghum, but both earliness and the absence of tannin make it more susceptible to birds. New pearl millets have been developed with bristled ears for bird control. The millet variety ICMV-221 has been pre-released (SECID, 1999, p. 5. 5).

Despite repeated probing of the former DG of KARI (Dr. N'Dirito) and the main promoter of this white sorghum, (Lawrence M'Ragwa), we could not ascertain the KARI strategy to get these sorghums out to farmers and seed companies. In summary, both the short-season whites and the brown sorghums have been around for over two decades and there apparently is no systematic promotion program to get them onto farmers' fields in semiarid regions. Nor do there appear to have been successful breeding efforts to respond to new biotic constraints in sorghum, such as *Striga* and *Midge*, or innovations besides tannin for bird control.

One of our most immediate recommendations for KARI is to better connect with the networks of researchers working in the semiarid zone. Sorghum with some individual resistances are available in several places in the rest of the world (including ICRISAT, Texas A&M, and Purdue Universities). The United States Agency for International Development did support a sorghum-breeding program in the '90s through MIAC, but getting new sorghum material onto farmers' fields has apparently had a very low priority for KARI, the extension service, and seed companies. It is not clear why KARI is not better connected to networks of scientists working in the semiarid zone both in Sub-Saharan Africa and in the rest of the world. Genetic material with a broad range of traits is available for the cost of postage.

KARI has the human-capital capacity and the stations to be active in adapting water-retention/soil-fertility techniques to a wide range of soil, altitude, and crop system characteristics in the semiarid zones of Kenya. The high returns from these combined activities have been frequently demonstrated (see the references in the technology section of this report). There has been some investigation by KARI of drip irrigation for female farmer vegetable producers and of better utilization of micro dams for households, animals, and supplemental irrigation (interviews with soil-water professionals in KARI). However, KARI is largely ignoring what is going on elsewhere in the rest of the world in water retention/soil-fertility management and has no systematic research plan to remedy this deficiency for the drylands.¹² With the deficits in agronomic research and with the lack of breeding improvement, little applied or adaptive research is being done for crops in the semiarid areas.

Most of our recommendations above have been in the very applied fields of agricultural research. However, ongoing basic research is also being undertaken on the molecular basis for drought tolerance in many institutions, including CIMMYT, Texas Tech University, and ICRISAT. KARI needs to maintain contacts with the individual researchers and institutes. CIMMYT is involved in new exploratory activities on drought tolerance in both wheat and maize. Translating the basic science concepts into useable products needs to be on the future agenda for the drylands in KARI.

¹² KARI headquarters had no research plan on water retention-soil fertility to give us, but we obtained a copy of the "Soil and Water Management Research Programme" from the Katumani station. It reported research done in the mid '90s. This report did not recognize the basic interaction between investments in water retention and soil fertility but tried to separate them. If both sufficient water and soil nutrients are lacking, it should not be surprising that overcoming one or the other of these constraints is not a profitable endeavor.

In the meantime, there is a substantial backlog of applied work in other regions that needs to be tested and then diffused in the Kenya semiarid zone.

There is another more basic problem that KARI has been unable to resolve. Since the Kenyan elections of 1992, donor funding has been cut back; the donors are negotiating with the government of Kenya to increase the efficiency and transparency of their expenditures¹³ and other structural reforms. In the private sector, a sharp decrease in operating funds would result in a large decrease in employment. Adjustments of this type are more difficult in the public sector. With restrictions on cutting employment, KARI expenditures on staff have become disproportionately high relative to operational expenses. With declining funds and unable to make drastic adjustments to employment, KARI is in crisis. This is indicated by its inability to pay bills; its many employees looking for ways to supplement their salaries, and low morale. Agencies, such as KARI, need flexibility to reduce employment and to sell more of their services to respond to the cyclical pattern of donor demand for their services. Another approach is to make a more convincing case for higher, more stable national support. Both strategies need to be pursued.

Since 1986, an Agricultural Research Fund was established to support applied activities with a competitive bidding process. Various donors — including USAID, the World Bank, and the Kenya Seed Company — have put money into this pot. Now the fund is open to KARI and non-KARI scientists. Presently per year, USAID puts in \$250,000, ODA \$80,000, and the World Bank \$4 million through loans to the Government of Kenya. Ultimately, the donors want to establish an endowment fund. To obtain these research funds KARI scientists have to compete. Many KARI scientists have not successfully made the transition to a competitive bidding system.

Presently, there is renewed interest in the poverty/nutrition problem in East Africa with all the recent published data on stunted growth among children. KARI has the opportunity to make some new initiatives for the semiarid zone. It can refocus its research and develop closer ties with NGOs and the state extension service so that these agencies can do more adaptive research and testing. KARI can also do much more charging for services in the high-rainfall regions and among the larger farmers. Some of KARI's staff could then specialize in serving this pay-for-service clientele. The threat is that KARI would then neglect the public good component of its research and provide inadequate servicing of the clientele that cannot pay for services.

Before completely succumbing to the bureaucratic disease of (a) inflexibility to respond to changing circumstances, (b) poor operating support to technical people, (c) little public responsibility, and (d) low morale, KARI needs to identify how it became so successful in the

¹³ A recent Kenyan publication pointed out that during the last decade, 60 billion Kenya shillings (833 million US\$ at an exchange rate of 72 Kenya sh/\$) of public funds has been misappropriated every year on average, earning Kenya a high rank among the most corrupt countries in the world, according to Transparency International (see "Is Kenya a Terminal Case?" *Market Intelligence*, p. 14).

high-rainfall regions and adapt its institution to the problems of semiarid regions now that poverty and malnutrition are back at the top of donor agendas.

Functioning of the National Extension System

Rise and Fall of the State Extension Service

Whenever there is a breakdown of the agricultural research/extension system as at present and with the failure to deliver new technologies to farmers in semiarid regions, the least eloquent members of the establishment end up taking the blame. The research system has produced little in breeding or agronomic innovations for the semiarid regions. Agricultural policy has been biased against the semiarid area in the Kenyan attempt to privatize and mainly service the high-rainfall regions. This is most obvious in the evolution of the seed industry where the major development has been increased availability of improved hybrid maizes. Both researchers and public policymakers eloquently pass the blame on to the public extension service for the failure to develop semiarid agriculture.

Without new technologies to extend or sufficient support from public policy for the semiarid zone, extension agencies retreat to slogans, such as the promotion of indigenous technology¹⁴ and the myth of local-variety superiority. These two concepts are now being heard all over the country and were frequently repeated in our field trip to Machakos. These two concepts can be summarized as the diffusion of best-farmer practices and this can be useful. However, the big gains from agricultural technology are with the application of science to agriculture, especially the rapid response to biotic constraints as they emerge, the utilization of higher input levels, and shifts to more valuable crops. These techniques need to be applied to semiarid regions unless the public-policy goal is to leave most farmers mired in poverty until, with falling birth rates and industrialization in one or two decades, they can be attracted off the farm.

As with KARI, the public extension service has been successful in the high-rainfall regions and had a boom period with World Bank funding in the '80s. During this time (1982-1992) the training and visitation model system (T&V) of extension was implemented. With high funding levels, extension employment increased.

After the 1992 elections, donor funding was substantially reduced. As with KARI, the extension service has had difficulty reducing employment; hence, operations and services had to be decreased

¹⁴ Another point of view also expressed on the team was that the semiarid zone should first take advantage of best farmer practices especially in the area of water retention such as bunds, terraces, and the equivalent of "zai" and in soil fertility in the improved use of manure and crop residues through coralling and composting. Then these areas would be ready to move into Stage II water retention technologies, inorganic fertilizers and new cultivars.

with consequent declines in morale and an inability to maintain services, especially in the drylands. With insufficient operational funds, lack of technology from the research system to extend and little public policy to support, the extension service was effectively paralyzed in the semiarid regions, leaving the field to the NGOs.

This is unfortunate since the structure of a strong service is still there with a total staff in 1999 of 11,912 of whom 7,197 are front line (deal with farmers). Of the staff, 3,159 have advanced training of at least a university degree (Chabeda, 2000). The T&V system with World Bank financing built up the cadres and increased investment in human capital. Unfortunately, the system was not sustainable and has the same problems when it tries to implement a reduction in force, as discussed with respect to KARI above.

Individual extension agents increasingly have made their services for hire available to the NGOs. The NGOs meanwhile had their own sources of outside funding but needed the technical support (and national legitimacy) from either KARI or the national extension program. There was a natural marriage and also increasing diversity in local research and extension activities. However, NGOs tended to be even more likely to settle for best-farmer practice diffusion than was the extension service prior to 1992. NGO performance in reporting feedback from new technology performance, after it took technologies from KARI, was even worse than that of the national extension service. KARI found itself with reduced demand for new technologies and even less farmer feedback on the technologies that NGOs did move into the field. Given the current weakness of the state extension service, any short-term strategy to increase the diffusion of new agricultural technology into the semiarid zones will have to emphasize development of more effective two-way communication channels with a much more diverse array of state, private and NGO extension actors.

Expansion of the Extension System: The Emerging Roles of the NGOs

There has been a dramatic expansion of the role of international and national NGOs in agricultural extension during the last five years. An analysis of two districts found that although the Ministry of Agriculture and other Kenyan departments continue to be the main sources of agricultural information in both districts (26-40%), NGOs (including churches) are the next most important sources (12-40%), followed by farmer-to-farmer interactions and neighbors/friends (1-26%).¹⁵

A number of factors are driving this trend toward increases in the number of persons in extension

¹⁵ Community-based organizations (CBOs) were reported as significant sources of information in both districts (9-23%) as were mass and print media (6-19%) and "stockists" (retailers) and traders (1-9%). One of the key differences between the high-potential Trans-Nzoia division and the semiarid West Pokot division was the much larger number of community-based organizations in the former than in the latter (260 vs. 80).

and agricultural input supply. Especially important has been a major shift in donor objectives toward increased privatization of functions once performed by the Ministry of Agriculture and a renewed emphasis on the state agricultural ministry's developing more rigorous financial accounting systems. In this revised policy context, the traditional role of government as an executor of agricultural development interventions has been redefined to put more emphasis on facilitating partnerships between local agricultural communities and a much wider range of government, NGO, and private-sector partners.

The national extension service of Kenya, under the Ministry of Agriculture, continues to oversee decentralized-division-level-trained male and female extension workers (with backup support from national-level specialists) who have direct ties with approximately 200,000 farm extension groups nationally (over 75,000 in the districts classified as semiarid).¹⁶ In the '90s the extension staff has experienced inadequate financial support for transport, travel, or routing operating costs for carrying technical messages to farm groups.

Responding to the decline in donor funding for extension, NGOs have been trying to fill this vacuum and have experienced substantial increases in demand for their services. Reflecting their historic commitment to social welfare issues, most NGOs see their role in agricultural development (technology development and extension) as part of a commitment to community development and food security.

There is extremely wide variation in the size and complexity of programs between and within NGOs. At one extreme are the large international NGOs, such as CARE, World Vision, and CRS, which coordinate multi-million dollar donor-funded disaster and development programs as well as smaller initiatives for specific districts. Of the 10 districts in the semiarid region in which World Vision supports agricultural development, all 10 of World Vision's programs are classified as Area Development Programs with annual budgets that range from \$100,000 to \$300,000. At the other extreme are a large number of small national NGOs, many of them religious-based, that receive small grants from the international religious organizations to which they belong. In addition to size, the Kenyan NGOs vary widely in terms of the sophistication of their agricultural programs.

The very simplest programs involve the provision of seeds and tools. The NGOs' most important sources of information on new technology and improved seeds are KARI and its research stations. The NGO desire to promote "seeds and tools" and improved agronomic practices creates their demand for extension workers.

¹⁶ In addition, there were a number of youth groups. Senior women in the agricultural extension unit described several specific instances in which youth clubs in the semiarid areas had been successful in passing new information about crop varieties or livestock production techniques to their elders.

Some NGOs (national as well as international NGOs) train and hire their own agricultural extension staff. Others “borrow” government staff by paying the costs (fuel, transportation, food, and expenses) of extension workers’ time on specific interventions in the NGO programs within the extension workers’ mandated zones. This type of collaboration is widespread and occurs with the tacit approval of the Ministry.

The IARCs, CRSPs, and KARI recognize that NGOs have direct contacts at the grassroots level, which facilitate their ability to work with local farmers for the development and extension of new technologies. They note, however, that the results of this collaboration have been mixed. One of the shortcomings most frequently identified by NGO, extension, and research leaders was that many NGOs failed to extend the recommended practices coming out of KARI.

Especially egregious in the eyes of many researchers is the traditional aversion of most NGOs to inorganic fertilizer, which in semiarid regions often needs to be combined with water-harvesting technologies. The technological naïveté of many of the NGOs is reflected by their almost complete failure to report farm-level results from the cultivation of seed they obtain from KARI. There are a number of notable exceptions (box below; Omanga 1999; Onyango and Umayya, 1999; CIMMYT et al; KARI, 1997; Odhiambo, n. d. ; Otto, 1997; Njuguna et al.,1996).

Box 1

**Results of On-Farm Trials of Drought-Tolerant Crop Varieties,
Muthetheni (1998-1999)**

Before the rainy seasons of March 1998, October 1998, and March 1999, the Mbaa Muthetheni Development Self-Help Group (MMDS) under a development program of the Missionaries in Action Pentecostal Fellowship Church (MAPF) in Mbaani (Machakos district) with financial assistance from Dorcas Aid International Africa, distributed seeds of drought-tolerant crop varieties of maize, sorghum, millet, beans, and cowpeas to 40 farmers. These farmers tested the varieties in small quantities, rated the performance of these varieties, and then disseminated the results of their experiences to all 420 farmers of the MMDS (divided over 10 sub areas). The results of these trials, including a detailed analysis of farmer trials in the Muthetheni area and in comparison with similar tests in the Yatta plateau region of Machakos district, were published in a detailed report. (Van Tol, 1999)

The KARI, extension, and NGO staffs involved in successful programs with farmers (including export of pigeon pea discussed earlier) cited a number of common features of those exceptional programs, which had been successful in building ties and promoting technology from KARI including:

1. A relatively high level of technical capacity within the NGOs in terms of both senior and junior agricultural development staff
2. Elaboration of concise memoranda of understanding (MOUs) to clearly elaborate the roles and financial expectations of each of the partners
3. A high level of technical support and backstopping from their international leadership¹⁷ for the religious NGOs.¹⁸

The recently expanded role of NGOs in Kenyan agriculture has precipitated a great deal of interest among NGOs and foreign donors. One example has been the collaboration of IRDC with World Vision and the Kenya-based Capacity Building Innovation Network (CABIN) to strengthen agricultural NGO financial management and strategic planning skills.¹⁹ Other efforts include Christian-worker conferences organized on agriculture, such as the ECHO/AISRED conference on Agriculture and Food Security in Eastern Africa (held in Kenya, Oct. 12-15, 1998) which brought together 98 agricultural specialists from small- and medium-sized NGOs in East Africa with the largest representation from Kenya.

Implications for the Future

The increased diversity of actors participating in technology diffusion presents a host of new opportunities and constraints. To date, however, there are only the first tentative movements to adapt strategic planning and administration to this recent shift. Although donor-funding through

¹⁷ The Catholic Relief Services (CRS) leadership in Baltimore, Maryland (USA) observed that their agricultural programs in East Africa have some of the strongest collaborative ties with the International Agricultural Research Center (IARC) system of any of their programs worldwide. One factor which they consider to have reinforced this collaboration was the agency's decision to create a new position of regional agricultural advisor, based in Nairobi.

¹⁸ One example is ECHO (Educational Concerns for Hunger Organization) a non-profit, Christian organization based in Fort Myers, Florida (USA) which strengthens missionaries and national churches as they assist small scale farmers. ECHO has been a major source of technical information and support for the NGO networks affiliated with AISRED (African Institute for Scientific Research and Development) in Kenya (see AISRED, 1998; Post and Ole Sena, 1999; Mbatia and Ngechu, 1999).

¹⁹ Although CABIN capacity-building efforts have not focused specifically on agricultural technology, the director has a Ph.D. in agronomy and sees the potential for this specialization.

NGOs presents KARI and the extension service with many new opportunities for funding demand-driven research, there are only a few examples of this taking place, such as the pigeon pea case.

The trend toward informal division-level exchange between the Minister of Agriculture and the NGOs is even more pronounced than the informal relationships between the NGOs and KARI. These relationships gain in flexibility from the high level of division-level informality but lose in terms of missed opportunities for further strengthening from trained Ministry staff. These informal arrangements may even increase costs since the NGOs often have to hire to fill positions that could have been filled by members of the extension staff either through a formal loan arrangement and/or some arrangement to simply pay their operating costs.

For NGOs to fully engage in the system, they must address the issue of technological capacity up front. Specifically, donor agencies and the international offices of these agencies need to be much more cautious in supporting agricultural development in NGOs that do not have the requisite technical leadership and ties to supportive agencies (including KARI, the IARCs, CRSPs and the national extension service). KARI could facilitate this process by making itself more accessible through a series of division-level presentations to NGO group meetings as well as group meetings of the major NGO networks such as CABIN, the food-security NGOs, AISRED, and ECHO's Kenya affiliates.

Gender Roles in Technology Adoption

Sorghum/Maize

Women play a major role in the rapid diffusion of new cereal cultivars. A recent survey of 1,400 maize growers in Kenya found that more than 40% of the maize farms in Kenya are managed by women. Despite less access to inputs and other agricultural services, female maize managers achieved 90% of the yield levels realized by male managers. The researchers concluded that while women cultivated smaller plots and had less access to education, credit, extension, and mechanical means of cultivation, they adopted improved production methods at rates similar to those of male farmers. Women can, therefore, be considered as prepared as men to adopt new technologies. With less effort by extension, female farmers can achieve gains similar to those of male farmers in maize productivity (Salasya and Hassan 1998, p. 77).²⁰

Part of the explanation for the rapid switch of urban and rural preferences to shorter-cycle maize can be attributed to women's preference for the less labor-intensive processing attributes of maize.

²⁰ This confirms the results of an earlier three-district survey of 706 randomly selected households in the districts of Kakamega, Muranga, and Kilifi (Saito et al., 1992, p. 79) which showed that with existing endowments (e. g., lower educational and training levels as well as less access to inputs and credit), men's mean gross value of output per hectare was only 8. 4% higher than females. This study suggested that "if women had the same access to resources as men, the value of their output would increase by 22%, which would make their productivity higher than that of male farmers" (*ibid.*).

The differences in processing and preparation times is an important issue for women in determining their choice between maize and sorghum/millet.

Grain Legumes: Pigeon Pea, Grams, Cowpeas

Women farmers are likely to play a large role in the dissemination of new higher-yielding, drought-resistant grain legumes which are “women’s crops” in many semiarid zones. One outstanding feature of these crops, which they share with popular horticultural crops and small-scale livestock operations, is that the ability to harvest over an extended period facilitates independent marketing by women.²¹ Many senior women extension specialists were concerned that large-scale government and foreign-donor investment in the development of new higher-yielding grain legume varieties and market development might encourage farmers to convert them to “male crops,” as happened with introduction of early maize as a male crop in the 1970s and 1980s.

One positive factor in women maintaining control of these new activities is the demonstrated ability of highly organized women’s groups to overcome the marketing constraints associated with new crops. For example, the Everest Food Company contracts enabled several women’s groups to market almost their entire production of fresh pigeon peas at competitive prices even with a steady increase in the number of women farmers moving into these joint production efforts.

Women’s groups have long been a key feature of women’s survival strategies in both rural and urban settings. In addition to their role in labor-sharing, emergency aid, and the institution of the merry-go-round (circular savings group), they provide one of the few socially acceptable ways to retain household income for personal and children’s expenses, such as school fees, health care, and improved housing. The size and dynamism of these traditional groups — which already were a pronounced feature of the Kenyan social landscape at independence — were given impetus by the decentralization of extension and research that occurred as a result of the 1984 rural development legislation.

The Kenya government has emphasized the critical role of contact groups for extension. Under the Second National Extension project (NEPII) utilizing the T&V method, all front-line extension staff were instructed to meet groups rather than individual farmers at each contact point. Women’s groups received extension advice through mass-media programs and quarterly workshops at the local level. At the workshops, group representatives met with local farmers and were introduced to new technologies and information which they then passed to their group members (Saito et al., 1992, p. 58). The T&V program in the national extension service helped to strengthen the pre-existing base of women’s groups’ adoption of new higher-yielding cultivars and associated technologies.

²¹ There was widespread consensus among the senior female extension agents and researchers interviewed that women prefer investing in crops (labor-intensive as well as less labor-intensive) which produce harvests that they themselves can market. Cereal crops (which tend to be quite bulky) require them to rely on paid labor and/or male kinsmen for marketing; this reduces their control over the profits.

Presently, 25 years after the first concerted efforts to strengthen female groups as part of the national extension effort, the national extension service estimates that its district-level extension officers have direct contacts (past and present) with 233,692 registered extension groups. More than 70,000 of these registered groups are in districts characterized as semiarid, according to the Home Economics Division of the Ministry of Agriculture, Nov. 1999. The Ministry of Agriculture production unit responsible for collecting and analyzing all production data in the country estimates that 95% of these groups are comprised exclusively of women (others are characterized as mixed).

Progress and Status of Women

Since Independence, the Kenya government has made substantial progress in making the agricultural extension service more useful for smallholder farmers in general and women farmers in particular. The findings of a well-known study of smallholder farmers in western Kenya in the mid-1970s found that there was persistent and pervasive bias against women farmers in the delivery of agricultural services (ILO, 1986). More recent research, conducted as part of the Women's Agricultural Productivity in Africa (WAPIA) survey, found that female farmers were as well served as male farmers (Saito et al., 1992, p. 54). An estimated 13% of farmers surveyed by WAPIA — both male and female — were in contact with the extension services, the same percentage reported in a T&V evaluation (Saito et al, p. 55).

The official number of women contract farmers increased from 10% in 1986 to one-half of all contract farmers (in 1989-1990) as a result of a concerted effort by the Ministry to target women farmers as part of the T&V program. Especially important as a result of the targeted hiring practices of the 1970s and 1980s is that an estimated one-third of the extension agents in the Ministry today are women. One important result of the WAPIA survey was to suggest that the gender of the extension agent was not perceived by either male or female farmers as a major constraint on communication except on certain themes (Saito et al, p. 59).²²

The results of this impressive investment by the Kenya government and international donors in the 1970s and 1980s represent a major asset that can be capitalized upon to address some of the technology concerns identified in this study. Indeed, our initial interviews within the Ministry and NGOs suggest that a great deal of this expertise is already being accessed through the district-level extension service's willingness to collaborate with the expanding base of national and international NGOs. Any concerted attempt by the national government in general, and KARI in particular, to

²² Three-fourths of both men and women in the WAPIA household survey and over two-thirds of female farmers in the WAPIA extension survey in Machakos and Muranga indicated that they were comfortable with either male or female extension agents, and over three-fourths of the agents in the Machakos and Muranga division had no gender preference in terms of their target audience. On the other hand, a substantial number of male agents (42%) indicated problems working with individual women and had difficulty delivering messages of particular relevance to women, such as labor-saving issues, nutrition, and childcare (*ibid*, p. 59).

unlock this potential must explore new ways of negotiating district-level cooperation between the better-funded NGOs²³ and the national extension service.

One major advantage of Kenya, compared with many of its neighbors, is its strong base of educated female scientists (approximately one-fifth of the agricultural scientists in KARI). In the absence of affirmative action targets, the KARI female scientists have not benefitted from the same access to educational advancement as the men. At the Ph.D. level, women are only 10% of the male number and 28% at the M.S. level. Unfortunately, with the general contraction of research funding, female scientists are obtaining fewer opportunities for educational advancement, are winning few competitive grants, and appear to be discriminated against in government line funding. These skewed educational and funding patterns appear to be more a response to scarce resources rather than any deeply entrenched pattern of gender discrimination. Nevertheless, they can have very negative impacts by creating new patterns of gender discrimination.

Responding to Lessons Learned

Improving incomes in the low-rainfall zone has not only a welfare effect in this region of concentrated rural poverty²⁴ but can also help take some of the population pressure off the medium- and high-potential zones. However, the principal reason for developing the semiarid region is its agricultural potential. When slightly more water is made available and soil fertility is increased, semiarid regions have a comparative advantage of more sunlight and less disease over higher rainfall regions, as demonstrated in California, Israel, and Australia.

1. Given Kenya's traditions in water harvesting, it is especially unfortunate that the government of Kenya has not continued to do adaptive research and then promotion, with state extension and NGOs, of different combined water-harvesting/soil-fertility improvements in the various semiarid agroecological zones. Especially serious is the failure to move to Stage II water retention techniques and to combine water retention and soil fertility improvements in both research and extension activities for the semiarid zone.
2. Since the '60s, the plant breeding establishment has not supported the semiarid regions in developing new cultivars for the improved agronomic environment that respond to (a) increased water availability and higher soil fertility (1 above), (b) new biotic constraints in the cereals and other crops of the drylands, (c) or even in moving along seed production activities in the private sector so as to make the new white-seeded sorghums more widely available.

²³ The better funded NGOs have more technically trained NGOs as well as excellent contacts with farmers.

²⁴ Poverty rates for the country are 46% in rural areas and 29% in urban areas. Poverty was defined in 1994 as 1490 Kenya Shillings per month in urban areas and 978 in rural areas (Kirk et al., 1999, p. 3).

3. An important lesson from the pigeon pea exporting case is the focus in the early introduction process on (a) identification of the markets and (b) making contacts between exporters and producer groups. System interactions from markets to production have created substantial interest in research and extension organizations.
4. Kenya has a tradition of entrepreneurial activity. It has a breeders' rights law to generate revenue for KARI. It is privatizing the Kenya Seed Company but has done almost nothing to insure or increase the availability of high-quality seed for the semiarid zone.²⁵ Individual scientists or extension agents support the community-based seed production activities.
5. Neither KARI nor the national extension service have responded to donor cutbacks after 1992 by making substantial employment reductions. Hence, services have necessarily been sharply curtailed. Therefore, both agencies are now fairly ineffective, especially in semiarid regions. The two agencies have impressive records of technology development, adaptation, and diffusion, especially in the high-rainfall regions. They are capable of orienting more of their activities to semiarid zones with organizational changes and some financial support.

Organizational changes which would help strengthen KARI include better networking with IARCs, universities, and other organizations working for the semiarid regions and developing new relationships, and even financing so that more of the adaptive research required in so many different agroecological systems can be done by the state extension service and NGOs.

For the state extension service, an especially important potential contribution would be activities such as more trials of the combined inputs of water retention, fertilizers and new cultivars to facilitate the growth of the input (seeds, fertilizer) and product (identifying and facilitating demand growth for semiarid agriculture) markets.

6. A number of NGOs have come in to fill the gap in research and extension services in the semiarid zone. Unfortunately, most of them have substantially under-invested in their own technical expertise in agriculture. They have also not provided feedback to the research establishment on the farm-level performance of the new technologies which they obtained from KARI or other sources. Government officials and NGOs have generally recognized these deficiencies and have been attempting to resolve them.
7. Women have benefitted from the processing and preparation advantages of maize and rice in the substitution of these cereals for sorghum. For the new white sorghums there are nutritional advantages and now the processing preparation technologies are becoming available for

²⁵ The exception here is M'Ragwa's work with small producers to increase output of KARI/Mtama 1. As noted before, we could not get any data on production, sales, or where the seed went other than the informal report of much of the output going to NGOs for southern Sudan.

sorghum. Some private sector and public home economics interventions are needed to communicate these techniques.

8. With strong women's groups and strategic production and marketing information, it is possible to increase the income received by women, as illustrated by the increased exports of pigeon pea. It will be interesting to see if men attempt to take over this crop as exports continue to increase as occurred with the early maize varieties.

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Interviews

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Uganda

Progress in the '90s With the Return of Stability

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Acronyms

ADC	Agricultural Development Centers
ADF-USA	African Development Foundation - United States of America
ARDC	Agricultural Research and Development Centers
AEP	Agricultural Extension Project
AETRI	Agricultural Engineering and Appropriate Technology Research Institute
ARTP	Agricultural Research and Training Project
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BUWOSA	Bukedea Women Strugglers Association
CBO	Community-Based Organizations
CDO	Cotton Development Organization
CEI	Commodity Exports International
CIMMYT	International Maize and Wheat Improvement Center
CORI	Coffee Research Institute
DFI	District Farm Institute
DFID	Department for International Development
FORI	Forestry Resources Research Institute
FOSRI	Food Science and Technology Research Institute
HIPC	Highly Indebted Poor Countries Initiative
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
ICRC	International Committee for the Red Cross
IDA	International Development Association, World Bank
IDEA	USAID Development Program- Investment in Developing Export Agriculture
IDRC	International Development Research Corporation (Canadian)
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Center
IITA	International Institute for Tropical Agriculture
IPM	Integrated Pest Management
KARI	Kawanda Agricultural Research Institute
KDA	Karamoja Development Agency
LIRI	Livestock Research Institute
MAAIF	Ministry of Agriculture, Animal Industry, and Fisheries
NAARI	Namulonge Agricultural Research Institute
NARO	National Agricultural Research Organization
NAROSEC	Secretariat of the Ugandan National Research Agency
NGO	Non-Governmental Organization
NSCS	National Seed Certification Service
NURP	Northern Uganda Reconstruction Program
OxFam	English based NGO
PEAP	Poverty Eradication Action Plan
PMA	Plan for Modernizing Agriculture
SAARI	Serere Agricultural Research Institute
SAIMMCO	Soroti Agricultural Implements and Machinery Manufacturing Company
SDDP	Soroti District Development Program
SG2000	Sasakawa Global 2000
SOCADIDO	Soroti Catholic Dioceses Development organization
SWOT	Strengths, Weaknesses, Opportunities, Threats
T&V	Training and Visitation model
UOSPA	Uganda Oilseed Producers and Processors Association
USAID	United States Agency for International Development
USP	Uganda Seed Project (now Uganda Seeds Ltd.)

Economic Conditions

In 1999 the population of Uganda was 21.6 million, growing at a 2.6% rate with 85% rural. Per-capita income in Uganda was \$103 in 1998. More than 80% of the population was engaged in agriculture but this sector only accounted for 45% of GDP (gross domestic product), hence the low incomes in the sector. Annual economic growth was impressive in the '90s, ranging from 4.5% to 10.6% over the period 1994-1999 (Republic of Uganda, 1999, b and d).

Food-crop growth rates were erratic in the last decade, with declines in two of the years. In spite of generally adequate rainfall and the myth that local soils have high fertility, there was increasing concern with inadequate nutrition and food insecurity, especially in semiarid regions. One governmental objective is to increase employment rapidly in the secondary and tertiary sectors so that the agricultural sector can be reduced (Republic of Uganda, 1998 b).

The semiarid regions, especially Karamoja, have experienced 20 years of civil disturbances (1971-1992) that destroyed most of the research and extension infrastructure and contributed to the breakdown of the traditional cropping systems and the degradation of soil fertility. Widespread cattle-rustling depleted capital stocks and encouraged more emphasis on crop production. Soil depletion, inadequate investment in water harvesting, and the failure to develop inorganic fertilizer distribution systems are principal constraints to introducing new agricultural technologies.

In the semiarid north, after the disruption of 20 years, a rebuilding process is underway. In the '90s there have been some notable successes and the research institution (NARO) is strong and has a good reputation. Unfortunately, the many foreign involvements of Uganda have been absorbing increasing quantities of resources and this may begin to affect the financing for NARO and other agricultural activities.

Farming Systems

Only 7% of Uganda by area and 2.4% of the population can be classified as semiarid ¹ (400-800 mm of rainfall) (Table 1, Fig. 1). So Uganda has very little true semiarid region compared to the other Horn countries. Another 30% by area and 29% by population has been categorized as transition semiarid (800-1200 mm per year). Here the soils are sandy so infiltration is often a problem and the bi-modal rainfall can be irregular. These combined areas are referred to as the Cattle Corridor.

¹ For the other countries in this Horn of Africa study rainfall above 800 mm was considered outside of the semiarid zone. Due to the irregular distribution of the predominant bi-modal rainfall and the frequent occurrence of sandy soils with high infiltration, the semiarid definition is expanded here.

Table 1. Uganda's semiarid farming systems

Farming System (District)	Land %	Population %	Rainfall (mm)	Temp. Range	Soil Type	Land Use
Karamoja (Moroto, Kotido)	6.8	517,300 (2.4%)	400-800 Unimodal	25-40° C	Sandy to sandy loam. Vertisols relatively rich in some places. Their physical characteristics limit utilization: swell and shrink	Most land is arable but lies fallow. Sorghum, pearl millet, pigeon pea, cowpeas, sesame. Cattle production is also important.
Teso (Pallisa, Kumi, Soroti, Katakwi)	7.2	1,466,000 (6.8%)	800-1200 Bimodal	25-35° C	Deep sandy to sandy loams. Nutrient supply low. Crops expected to respond to N and phosphorus	Most land is farmland (63%). Low moisture levels sometimes restrict crop growth. Sorghum, cassava, sweet potatoes, cotton. Animal traction is key.
Northern (Gulu, Kitgum, Apac, Lira)	10.5	2,130,100 (10.0%)	800-1200 Bimodal	24-35° C	Sandy, sandy clays. Acidic, low in organic and general nutrient supply. Crops likely to respond to N and P.	Most land is arable but much is fallow. Virgin land is available but people are reluctant to move from ancestral lands. Finger millet, sorghum, maize, sesame, beans, cassava, cotton. This is the main area for pigeon pea.
Cotton-Millet-Banana (Nakasongola, Luweero, Mbarara, Ntungamo)	12.2	2,633,300 (12.2%)	1000-1200 Bimodal	25-35° C	Sandy soils, often with gravel. Acidic with low calcium. Soil structure weak, water infiltration rapid often restricting crop growth.	Arable. Northern part is woodland. Banana, finger millet, beans, cotton, maize. Cattle production.

Source: IGAD/ INTSORMIL Interviews, March 2000.

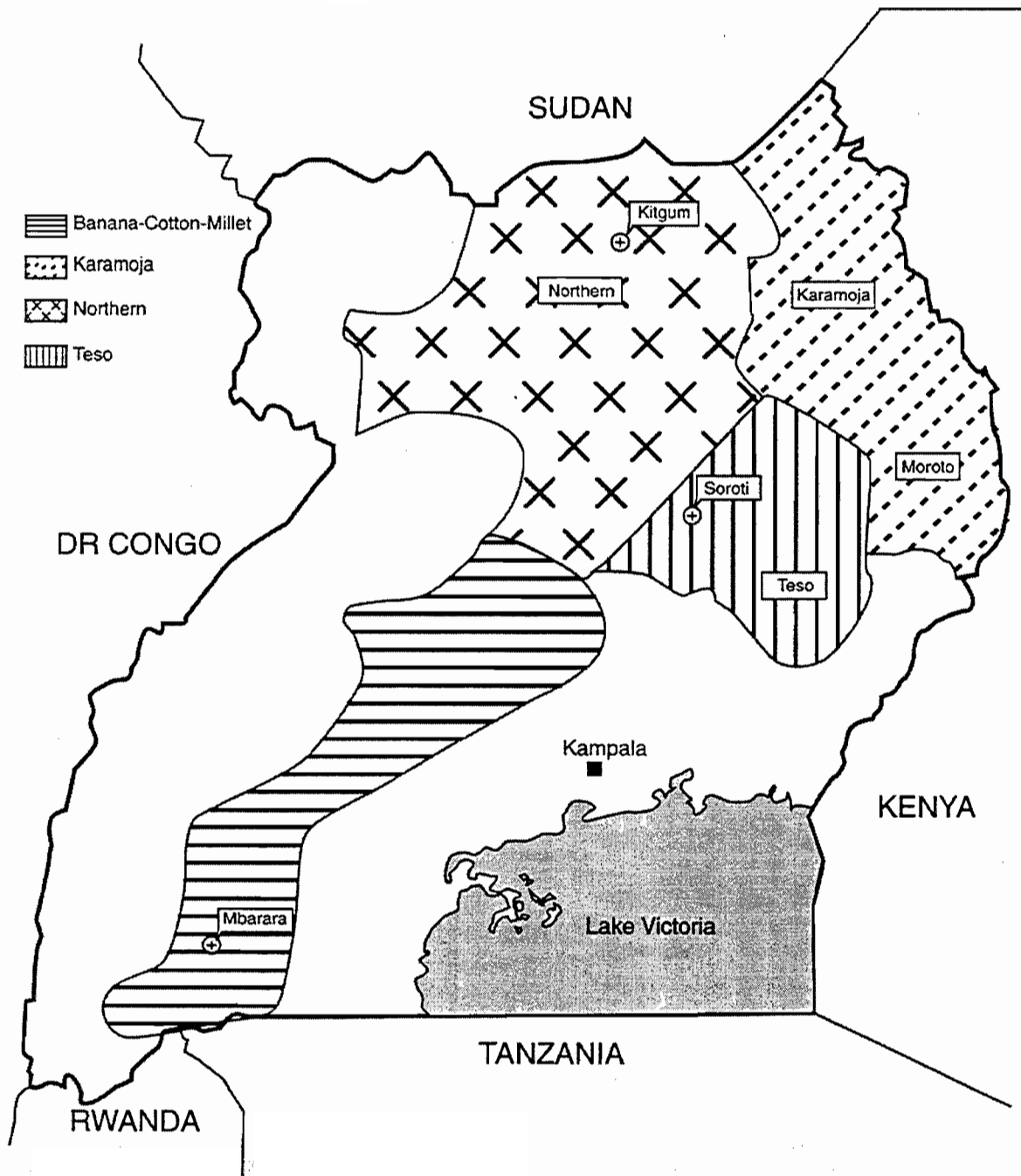


Figure 1. Farming zones of semiarid Uganda
 Source: Adapted from NARO files.

With the wide range of rainfall distribution and soil variability,² there are a large number of crops in semiarid regions, including cotton, sorghum, pearl and finger millet, groundnuts, cowpea, pigeon pea, sesame, grams, sunflower, sweet potato, and cassava. Agricultural productivity is low with minimum use of purchased inputs. Use of animal traction has been common for land preparation but not weeding. Animal traction was significantly reduced by widespread rustling during the civil disturbance period, especially in the late '80s. Most women farmers do not use animal traction. Post-harvest losses are high due to poor storage and limited market outlets.

Successes and Potential Successes

Cassava

Cassava has been promoted all over the country as a reserve food crop and in some periods farmers were even pressured to produce cassava as an insurance policy to guarantee a sufficient supply of calories.³ Cassava is the second staple in the country ranking after only bananas in area, production and per capita consumption.

Cassava production collapsed in the early '90s with the continuing pandemic of cassava mosaic virus, which can cause 80% to 100% yield losses on individual plants. Ninety-seven percent infection in the country was reported in 1994 (Bua and Acola, 1998, pp.5, 6, 9).⁴

With help from the International Institute for Tropical Agriculture (IITA) the National Agricultural Research Organization (NARO) identified resistant cultivars and tested them for local adaptation. With cuttings, NARO quickly disseminated resistant cultivars. In five years production was back up to the levels before the pandemic. This was a major success for Uganda's research and extension system.

The downside for cassava and most food staples is that once normal production levels were achieved, the price collapsed. This indicates the need for more systematic efforts to search for market-expansion potential at the same time that yield-increasing technologies are being

² The soils are generally light sandy clay loams to dark clay loams which make them light and easy to cultivate. The productivity of these soil types can be described as moderate in the Teso region (Soroti, Katakwi, Kumi and Pallisa); moderate to poor in the Acholi and Lango regions (Gulu, Kitgum, Lira, and Apac); good to poor in the West Nile region (Moyo, Arua, Nebbi and Adjumani) and *moderate to poor in the Karamoja region* (Moroto and Kotido) (Langlands, 1974).

³ There are nutritional problems with a diet heavily dependent upon bananas and cassava for calories. The cereal/legume combination is a much better balanced diet. There needs to be public concern wherever elements of the population become heavily dependent upon root crops.

⁴ A series of other production problems exist in cassava production but would not explain the dramatic decline in yields in 1993 and 1994 (Bua and Acola, 1998, pp. 7,8).

introduced. The price collapse from the lack of market expansion⁵ is a limiting factor for many food crops. It is critical to work on demand expansion programs for the traditional food crops when new technology is being introduced.

The lesson learned from this major success story in diffusing mosaic resistant cassava cultivars was that the Uganda research system (NARO) can respond quickly to a crisis and can achieve farm-level effects with the cooperation of extension and NGOs. The seed supply was simple since cuttings of resistant material could be used. The recent cassava experience indicated that if markets are not developed as the technology is introduced, prices collapse thereby discouraging the utilization of improved production techniques.⁶

Cotton

Cotton has been an important cash crop but yields were low (300 to 500 kg/ha) due to low levels of use of inorganic fertilizers and pesticides. Before the collapse of the cotton sector in the '70s, Uganda was producing 497,000 bales (1970) of well-known, high-quality, medium-staple cotton. Ida Amin expelled merchants and managers of the gins. Cotton research ceased and there was a mixing of the types of cotton, leading to an international loss of the product quality reputation.

In the '90s the cotton sector has been recovering. In 1992 with a World Bank loan, the NARO Serere station at Soroti reinitiated cotton research. Researchers selected new cultivars, developed an integrated pest management package (IPM), reduced the number of required sprayings from four to two, and did testing for inorganic fertilizer recommendations.

Two other World Bank loans in 1993 and 1995 reinforced the reestablishment of the cotton sector. Over half of this cotton production is concentrated in the semiarid north. Cotton exports increased from 7,819 tons in 1991 to 18,975 in 1997 (Uganda 1999d, p. 85).

The cotton sector can pay for its research and extension services, thereby enabling the expansion of services to the food-crop sector in the semiarid regions. Both the cassava and cotton research and diffusion success stories took place in the mid '90s illustrating how quickly the research system can move once domestic stability is achieved.

Other Technologies

Other technologies have been successfully diffused within Uganda's semiarid region since 1992. They include a high-yielding, blast-resistant finger millet (PESE 1), and a series of high-yielding, drought- and rosette-resistant groundnut varieties (IGOLA 1, Serenut 1R and 2R). There were no

⁵ In economic terms this is referred to as *low price elasticities of demand*. There are multiple potential uses of cassava including use as a feed.

⁶ A similar problem occurs when good rainfall conditions results in a large supply increase. Consumers can only consume so much of their basic staples. So new market development is an important concern for traditional food crops.

diffusion studies so reported success is based on informal expert opinion from the Serere station (see Table 2).

Cereals for the Drylands: Maize and/or Sorghum

Maize. NARO's maize-breeding program has been producing shorter-season material with multiple disease resistance, including the OPV, Longe 1, and two hybrids, Longe 2H and Longe 3H. All of these are medium-period maizes most appropriate for central and western Uganda. Introduced only five years ago, Longe 1 is being disseminated throughout the semiarid region. The new OPV LP 16 is earlier and uses the new CIMMYT (International Maize and Wheat Improvement Center) technique for drought resistance of shortening the time period between silking and flowering. This new maize cultivar (OPV LP 16) offers substantial market potential and is an excellent response by breeders to a number of emerging problems.

Substantial incentives and public policy support are necessary to avoid seed supply becoming a major constraint to getting the new maize cultivars into the field. Presently Uganda Seed Ltd. is shifting to a focus on hybrids for the prime regions. This is the typical response all over the Horn countries as donors continue to put pressure on the seed parastatals to become more profitable. They shift seed production out of OPVs and phase out of seed production for the semiarid zone concentrating on the high value crops for the most favorable production regions.

Sorghum. Sorghum is grown throughout Uganda with the largest concentrations being in the north, northeastern, and southwestern parts of the state, which are characterized as semiarid. The Serere Institute has released a number of new sorghum cultivars, both brown- and white-seeded, and three hybrids (Table 2). With fertilization and good agronomy, these cultivars can yield 3 to 5 mt/ha as opposed to .8 to 1.5 mt/ha of the present cultivars. The hybrids raise the yield potential to 4 to 6 mt/ha (P. Esele, personal conversation, based upon unpublished regional trial results, March 2000). There have been a limited number of demonstration trials on farmers' fields and Uganda Seeds Ltd. has been distributing some of these sorghum cultivars.

To date, however, most farmers are staying with traditional low yielding cultivars without fertilization. Why? There are three predominant problems with getting new sorghum cultivars onto farmers' fields.

Table 2. Diffusion of new cultivars in the semiarid areas of Uganda, March 2000

Commodity/variety	Semiarid farming system				
	Teso	Karamoja	Northern	West Nile	Cotton, Millet, Banana
Sorghum					
Seredo	++	++++ 1980s	+	+	0
		++ 1990s			
Sekedo	++	+	+	+	+
Epuripur	+	0	0	0	0
Finger millet					
Serere 1 (inactive1)	+	0	+	+	+
PESE 1	+++	+	++	+	+
U15	0	0	0	0	0
Pearl millet					
Serere Composite 1	0	++	+	0	0
Serere Composite 2	0	++	+	0	0
Maize					
Katumani (not NARO)	+	+	0	0	0
Longe 1	0	++++/0*	+	+	+
Longe 2H	0	++++/0*	0	0	0
Longe 3H					
Pigeon pea					
KAT 60/8	0	0	+	0	0
ICPL 87091	0	0	+	0	0
Cowpeas					
Large White H	+	0	0	0	0
Large White I	+	0	0	0	0
Groundnuts					
IGOLA 1	+++	0	+	+	+
Red Beauty (inactive)	++	0	+	0	0
Serenut 1R	+				
Serenut 2R	+				
Cassava					
Migyera	++++	0	++	+	+++
NASE 1	++	+	+++	+	++
NASE 11	++	+	+++	+	+
SS4	+	0	+	0	+
Cotton	All	All	All	All	All

0=non diffusion
 +=<1-5% Diffusion
 ++=5-10% Diffusion
 +++=10-20% Diffusion
 ++++=20%+ Diffusion

* Extremely high diffusion rates in higher-potential volcanic soils of Moroto district in southern Karamoja. Adoption tends to be by wealthier commercial farmers.
 All = All crop areas in this variety

Source: Informal Expert Opinion from the Serere station, February 2000.

1. **Markets.** In the early '80s Nile and Bell Breweries could not import barley because of foreign-exchange shortages and rationing so they used sorghum for malt. The resulting increase in demand for sorghum precipitated a substantial increase in sorghum production in Western Uganda in the early '80s. Unfortunately, once barley imports were resumed, this sorghum market collapsed. To date, there is only minimal sorghum use in the feed industry which is dominated by maize. Despite the adaptability of the new white sorghums for bread (when combined with wheat flour) there has been minimal adoption of this flour mixing. Except for the temporary use in beer, there has been little increased use of sorghum. Increasing market size will be a critical factor for the diffusion of these new cultivars. Otherwise prices collapse with good weather or the commencement of the diffusion process of new technologies.
2. **Birds.** The white sorghums' vulnerability to bird damage constitute another major constraint. The new cultivars are also earlier (90-100 days as opposed to 150-180 days), making them an even better target for birds. Fitting the shorter season sorghums into the shorter second rainy season is one option since bird damage tends to be less during that time period. A second option involves planting sorghum on large areas, which reduces the bird problem but is difficult to organize when a new cultivar is being introduced. Any long-term effort to resolve the bird problem will necessitate NARO breeding new cultivars with alternative resistance mechanisms for birds besides tannins. Tannins give bird resistance but reduce nutritional value for both humans and animals. The new white sorghums offer substantial nutritional advantages but are more susceptible to birds.
3. **Striga.** *Striga* infestation levels have increased markedly in the last decade seriously reducing sorghum yields. This has been attributed to the depletion of soil fertility, the reduction of the cotton area, and continuous cereal cultivation. Two research approaches are *Striga* resistant cultivars and/or higher fertilization levels.⁷

Water-Retention Technologies and Fertilizer

New cultivar introduction was very important in the '90s. Unfortunately, most farmers are practicing a cultivar-alone strategy with minimal adoption of other crop production technologies. Soil fertility is already a problem in much of the semiarid zone and will get worse over time as fertility is depleted with further cultivation, so yield gains from new cultivars alone are not sustainable.

One diffusion project(Sasakawa Global 2000) of new technologies in a semiarid area in the millet-cotton-banana farming system (Nakasongola region) showed that the lack of parallel investment in soil/water-conservation measures was a major factor affecting yields and long-term adoption rates. Specifically, 60% of the sample farmers did not continue with the package (seed and

⁷ Losses from *Striga* are associated with low soil fertility. With better plant development from higher nutritional levels plants apparently can resist better the parasitic weed.

fertilizer which they purchased with cash through project outlets) after the first year. Follow-up research by the project showed that the majority of the 60% of non-adopters were from the drier northern parts of the district, where soil moisture was an issue. This experience indicates that a single-minded focus on fertilizer, in the absence of complementary investments in water-harvesting, is unlikely to be successfully diffused in the semiarid zone.

The interaction between water-retention and fertilization technologies in semiarid regions was not surprising to NARO soil scientists. Nevertheless, there was no on-going experimentation on the combination except by NGOs. Terracing and bunds were associated with the colonial period and forced labor so there was much criticism of the high labor requirements for these activities. One farmer who the team visited on field research near Soroti was using various types of water catchment from the road, roofs, and trees and using it to irrigate citrus, pineapple, sunflowers, and sesame.

Conventional wisdom prevails that Ugandan soils are rich and inorganic fertilizers are very expensive. The soil scientists and most agricultural professionals vigorously deny the first but accept the second. Many soils, especially in the semiarid regions, are highly weathered and of inherent low fertility. Evaluation and demonstration trials have consistently shown substantial responses to N and P. Hence, these major nutrient levels will have to be increased.

Inorganic fertilizer prices have substantially increased; however, it is the fertilizer price relative to output prices that is relevant and higher levels of inorganic fertilizers will be necessary to increase crop output levels. So Uganda needs to be careful not to distort food prices and reduce the profitability of using the input packages necessary to increase and sustain crop yields. Often where cost calculations are made in terms of the cost per nutrient unit of N and P, inorganic fertilizers turn out to be cheaper sources of these basic nutrients. Increasing the profitability of inorganic fertilizers will often depend upon making more water available. Though lacking in the basic principal nutrients of N and P, organic fertilizer increase water and nutrient retention, biological activity in the soil, and provide other minor nutrients. So they are often useful complements to inorganic fertilizers.

One advantage of Uganda's semiarid regions is the established tradition of using animal traction to facilitate early planting and therefore take better advantage of the rainfall. SAARI also has a solid research base of tied ridgers and other animal traction implements.

Outside the Sasakawa 2000 trials cotton was the only crop within the semiarid region on which fertilizer was used and this was below recommended levels. Fertilizer recommendations have been

based on experimentation of the '70s. The primary exception to this general lack of recent empirical work was the response work on millet and sorghum funded by IDRC.⁸

The research gap is even more pronounced on water-harvesting techniques. To date, there has been no applied research on water-harvesting techniques in relation to any crop although researchers are aware of the problem and the fact that farmers do use a number of techniques (water channels in the Teso region; ridge and furrow systems and valley dams in Karamoja) to retain water in rainfed agricultural areas.

Improved Agronomic Technologies

Any strategy for sustainable yield increases for the semiarid regions must also consider how increased fertilizer use and water harvesting will increase the labor requirements for the crop cultivation practices—most notably weed management. The Serere Agricultural Research Institute (SAARI) has more than 10 years of data indicating losses as high as 60% on crops, such as finger millet, which can be attributed to weed competition. To decrease the costs of hand cultivation, SAARI researchers have developed an Ox drawn weeder. This weeder can reduce labor requirements for weeding by 80%.⁹

SAIMMCO, the recently privatized (1999) farm implement manufacturer in Soroti, is already producing weeders. More accelerated production of weeders in general and the Saari Ox weeder in particular would require SAIMMCO to have clear rights to produce the equipment that was originally developed by NARO. At present the less expensive Saari Ox weeder is not being produced by SAIMMCO because of the lack of clear technology rights. SAARI researchers predict that the availability of lower priced weeders would increase the area planted to higher-yielding sorghum and finger millet varieties.

⁸ After a recent study assessing constraints, NARO is undertaking a major reorganization of the soil science program and formulating priority research areas on soil productivity, including (1) appropriate fertilizer application rates based on an analysis of the economics of fertilizer in different semiarid farming systems; (2) region-specific recommendations for soil-fertility management; (3) recommendations for utilizing better soil micro fauna to improve soil fertility; and (4) identification of appropriate water-harvesting and conservation techniques.

⁹ This research, started in the 1980s, included a critique of existing weeders imported from other countries (notably Zimbabwe, India, and Britain) to develop a weeder that would be better adapted to northern Uganda. Special innovations that distinguish this weeder from the other imported weeders include the ease with which the weeders can be attached to the tool bar of the plow. Earlier planters came as separate units and were costly for Northern Uganda farmers.

Despite NARO's recommendations that the new cultivars be accompanied by a series of improved agronomic practices, farmers have tended to emphasize a cultivar-alone strategy with minimal adoption of other technologies, such as row cropping, inter-cropping and weed regimes, and timing of planting. The failure to use these improved practices and inorganic fertilizers substantially reduces the yields and the sustainability of the yields of these new cultivars.

Input Markets

The Seed Sector

Uganda has had a national seed parastatal (Ugandan Seed Ltd.) owned 100% by the government. There has been an important social service component to the activities of the Ugandan Seed Ltd. (formerly the parastatal Uganda Seed Project) reducing its profitability. With the privatization push from the donors in the '90s there has been pressure on the Ugandan seed company to become more profitable.

This shift to more profitable activities decreased the Uganda Seed Company's¹⁰ willingness to produce the crops targeted for the less profitable semiarid zone—notably sorghum, millet, and groundnuts. Sorghum seed sales in 1999 were less than half of the pre-1992 levels; millet sales were less than 5% of the 1991 level, and groundnuts were less than half. In contrast maize and bean seed sales, which were targeted for the higher rainfall zones, showed 50% and 100% increases, respectively (Table 3).

As a result of this restructuring open pollinated varieties and other seed needs for semiarid regions come from farmer groups and NGOs with SAARI or Ugandan Seeds Ltd¹¹ providing the Foundation seed. The revenue produced from sales of OPVs and other seed is an important source

¹⁰ There are also a number of private companies. These include Sukura Seeds (Mbale), Naseco (Hoima), UOSPA, Rutuku Seed Potato Growers Association (Kabale), and Commodity Exports International (CEI Ltd.) (Table 4). In theory, these companies sell certified seed that has been verified by the National Seed Certification Service (NSCS) since the late 1960s. Most of the private companies depend on NARO for the Foundation seed they use to produce local varieties. To date, no company pays any patent rights for the use of the NARO-produced cultivars.

¹¹ In line with the government's policy on privatization, the production, processing and marketing component of the Uganda Seed Project has been formed into a public company Uganda Seeds Ltd. In this arrangement, given the strategic importance of seed, the government retains 51% majority shares; 49% is divested to the private sector. The move to privatize the Uganda Seed Project is aimed at removing distortions and improving efficiency of making seed available to the farming community. Currently Uganda Seeds Ltd. has the largest infrastructure of all the seed companies in the whole country. It has a seed-marketing and distribution network consisting of 16 wholesalers and 200 stockists (Oryokot, personal communication, 2000).

of income for the SAARI Research Institute. A few NGOs and local governments have created project fields on which they reproduce the new Foundation seed under the supervision of their agricultural extension officers. SAARI researchers verify the seed quality.

**Table 3. Evolution of Seed Sales from Uganda Seeds Ltd.,
1988 - 1999 (metric tons)**

Year	Maize	Ground-nuts	Beans	Soy-beans	Sun-flower	Sorghum	Sesame	Finger Millet	Other
1988	594	46	170	25	3	--	---	--	--
1989	331	98	101	6	1	23	---	--	--
1990	285	107	52	31	1	38	---	--	--
1991	334	354	540	32	4	140	101	116	--
1992	763	52	93	101	16	145	16	--	--
1993	809	13	19	82	6	77	16	--	--
1994	1095	---	559	19	3	32	1	--	--
1995	355	4	385	33	28	20	2	6	--
1996	396	101	116	27	25	57	1	9	--
1997	846	31	334	34	3	29	--	16	9
1998	751	63	564	38	11	65	--	8	8
1999	1003	28	1,013	28	2	68	0.06	7	16

Source: Uganda Seeds Ltd., November 1999.

This type of informal seed production, "community-based seed production," depends upon NARO training and monitoring farmers (many of whom are current or former NARO employees) and/or NGO groups in the production and quality-control techniques associated with seed production. Although the community seed projects may help alleviate some of the most severe short-term shortages, they are unlikely to provide farmers with a stable source of quality seed supply over the long-run. The reasons for this are several. First, most of the current programs require high levels of labor input from the NARO scientists who are anxious to "push out" their new technologies. Generally scientists soon need to return to their principal functions and then the quality control of these community-based seed production projects deteriorates rapidly.¹²

Seed production is a complicated business with its various stages of Breeders, Foundation, Certified/Registered, and Commercial seed. Seed inspection and processing are major problems in these community-based seed programs. There are substantial requirements for good marketing and distribution skills. In the absence of proven quality control and superiority of the seed, farmers will not be willing to pay a price premium for the seed. Without the price premium there is no

¹²With small farmer seed producers it is very difficult to control problems associated with isolation and roguing.

incentive for farmers and researchers to do rigorous quality control. The advantage of a trademark or a private company is that the company has to take responsibility for quality control and, once established, can charge this prime premium for the additional services required.

There is widespread consensus among agricultural researchers in Uganda that the lack of private-sector seed companies constitutes one of the most serious constraints to the uptake of existing and new crop varieties. There is also an emerging consensus among NGOs and the government that some sort of integrated approach will be needed to address the problem at the level of research, extension, and public policy.

The Uganda government needs to encourage the entrance of private seed companies and set up economic incentives for this to occur, perhaps including breeders' rights with some breeders- rights payments made to the scientists developing the new cultivars (Table 4). This would stimulate these same scientists, who are often entrepreneurial, to participate in the development of private seed companies.

Table 4. Seed Sales by Private Seed Companies in Uganda, 1999

Seed Company	Commodity Type	Source of Seed	Quantity (mt)
Uganda Seeds Ltd.	Maize, groundnuts, sorghum, soybeans, finger millet, rice simsim, pigeon pea, sunflower, maize, beans, rice	Breeder seed from NARO	1,300
Sukura Agroindustries	Maize, beans, rice, wheat	Maize hybrids from Kenya and Zimbabwe, Uganda Seed Project	700
Naseco	Beans, soybeans, maize, groundnuts	Foundation seed from NARO multiplied by contract farmers in Nakasongola	20
Commodity Export International	Maize, beans, groundnuts	Maize hybrids from Zimbabwe, Foundation seed from NARO	900
UOSPA	Sunflower, soybeans	Multiplied seed from Uganda Seed Project	Data not available

Source: Individual interviews with seed companies. (Oryokot, 2000).

Some public service functions also need to be retained by Uganda Seeds Ltd. to insure that smaller markets and open-pollinated cultivars are adequately supplied in the new privatization movement until the seed demand is large enough for many of the smaller markets to interest the private sector. For example, returns for open-pollinated seed for the semiarid north are much less than the returns for hybrids or cash crops in the higher-rainfall regions.

A large number of national and international NGOs are currently-important players in the seed industry of the North both as suppliers (through the multiplication and distribution of seed through the informal sector) and as buyers. The private company, CEI Ltd. (Commodity Exports

International), for example, sells up to 70 to 80% of the seed it handles to NGOs, the International Committee for the Red Cross (ICRC), and southern Sudan (Table 4).

Very important problems for NGO seed production are:

- a. The continuing technical difficulties in maintaining seed quality especially with a large number of small scale seed producers;
- b. The propensity of NGO seed production creating barriers to the future entrance of the private sector. Concerned with keeping input costs low for farmers NGOs often attempt to keep the seed-grain price ratio close to one while a private sector looks for a ratio of around 8 to 10:1 to finance its quality control activities and research.

Fertilizer Markets

Fertilizer use is critical for the full impact of farmers' investment in the new cultivars. Without land productivity increases from higher soil fertility inputs, any technology strategy will not be sustainable because it will mine the nutrients and ultimately exhaust the soil.

As a landlocked country with inadequate rural road networks, fertilizer costs are high. Consequently, outside of the major cash crops (sugar cane, tea, coffee, and maize) fertilizer use is low. Until recently, fertilizer imports have been handled by four large dealers who function as agents for the major tea, coffee and sugar estates. In recent years, other private dealers have entered the sector.

One unintended consequence of the government's decision to subsidize fertilizer inputs for smallholder agriculture through a series of World Bank/International Development Assistance (IDA) and other funded agricultural-support projects in the late 1980s and early 1990s was to introduce a series of additional distortions into the private fertilizer market. For example, the KR-2 fertilizers were sold at approximately 50% of the import parity price in 1995. This high price differential and uncertainty in delivery discouraged the entrance of potential private-sector distributors.

One goal of the SG2000 and the USAID-funded IDEA project was to facilitate the Uganda government's program of combined policy reform, distribution network development, adaptive on-farm research, and extension. The objective of these integrated policies was to increase fertilizer consumption. Both SG2000 and IDEA have attempted to strengthen the internal distribution network for fertilizers within Uganda. There are now a total of 300 to 400 fertilizer stockists, predominantly trained by either the SG2000 or the IDEA projects.¹³

¹³ In comparison, there are 6,000 stockists in Kenya.

In the future it will be important to increase funding for more region specific fertilizer trials including improved water retention techniques.¹⁴ Also important will be importing higher-nutrient-level fertilizers and undertaking research on more efficient and lower-risk application methods. Techniques, such as applying N when there are sufficient rains, are a common method of reducing the riskiness of fertilizer use through a type of response farming. As demand increases over time the government may want to encourage the private sector to rebuild the phosphate factory at Tororo, that once supplied large areas of East Africa.

The Credit Market

A reason frequently cited for the lack of farmer interest in intensifying crops grown only for home consumption is the lack of credit for these crops. However, even small holders have other sources of cash besides agriculture, including off-farm work and remittances. Their “savings banks” are their animals. The problem of input use with food crops is not the lack of credit but the problem of convincing farmers that technology is available and that the cost of increasing their home consumption through increased purchases is as important as the market price for cash crops. Nevertheless, credit availability is expected to facilitate the diffusion of new technologies.

Unfortunately, credit is frequently considered the panacea for agricultural development. Many credit programs have been tried and repayment rates have generally been low as the tradition of repaying loans has not been established

A common characteristic shared by the successful commercial bank and private sector institutions was that they were directly linked to programs that facilitated farmers’ access to the necessary inputs and markets that they needed to increase their productivity and hence pay off the loans. The SG2000 and IDEA Projects offered guarantees to commercial banks to secure loans to stockists and smallholders associated with the projects’ agricultural programs. The Smallholders Cotton Rehabilitation Project (1993-1996) provided guarantees to the Bank of Uganda for loans that it accorded to individual smallholder cotton farmers for the purchase of oxen, ox drawn implements and pesticides. The credit program associated with all three projects had high repayment rates and encouraged the diffusion of new technologies in the intervention areas. There is also an expanding number of smaller semi-formal micro-finance institutions and “Village Banks” that followed the same model of linking credit to technology development and input supply such as the Bukedea Women Strugglers Association (Box 1).

Some recommendations based on this experience are:

1. *Strengthen Private and NGO Programs which Link Credit to the Production of Crops that have Internal or External Markets.* This correlation highlights the critical importance of linking

¹⁴ Most of the on-farm trials for fertilization in Uganda (including six of the eight districts included in the SG2000 trials) were conducted in the higher-rainfall areas. For the semiarid regions, this combined water-retention/soil-fertility research would appear to be a top priority.

credit to the support for inputs and marketing support. It will often be necessary to identify new markets for traditional food crops such as sorghum..

2. *Encourage SG2000 and the IDEA Project to Expand their Operations* in the semiarid areas and to (a) consider the need to reintroduce their earlier model of facilitating stockists' access to credit for inputs, and (b) conducting collaborative on-farm research with NGOs to develop more appropriate technical recommendations for the semiarid zones.
3. *Strengthen NARO/SAARI's socio-economic research on local patterns for financing agricultural innovation.* There are many sources of farmer income from remittances, off farm work and even cashing in of animal stocks. Credit is frequently overrated as a variable for encouraging technology adoption as compared with the availability of input and output markets and the farmer being able to observe the technology in the field. So better field data on these sources of income and how farmers decide to make investments are more important than another subsidized credit program.
4. *Strengthen government and NGO programs which facilitate the types of training and start-up credit that help farmers develop micro-finance institutions.* Many women's groups have been successful in using start-up credit to help individual members increase their purchase of agricultural equipment and inputs, raise yields and develop non-farm employment. Government extension and research could facilitate this development and simultaneously increase access to information about new technologies being developed and extended by NARO.

Box 1. The Bukedea Women Strugglers Association

From 1992 to 1995, Bukedea Women Strugglers Association (Teso region) administered the Bukedea women's oils seeds production project. As part of the project, there was a provision for credit for production which was used for purchase of sunflower and groundnut seed, insecticides and for contracted labor. There was also credit provided for purchasing animals for traction.. The production loans were made to the women in cash who then purchased the inputs from the open market and hired labor primarily for weeding primarily. At the end of the season the project purchased each individual's production and deducted the value of the loan plus interest from the purchase price. About 90% of these crop loans were repaid. The project originally anticipated that the repaid loans would constitute a revolving fund with which to fund future credits. Instead the money spent for purchasing animals was not repaid. Since 1995 the loan program has been discontinued but individual women continue to purchase their own inputs (without formal credit) and to sell on the open market. Nevertheless, the project was considered very successful in raising the income levels of these women farmers.

Source: IGAD/INTSORMIL, interviews, November 1999.

New Markets for Semiarid Crops

After introducing new technologies and improving input markets (seeds, fertilizer, credit), the expansion of new markets is the next most important constraint in the semiarid regions (Table 5). When soil fertility declines, as it has, farmers must purchase fertilizers. Intensification of production will not be encouraged if prices collapse with the increased production or good weather. When prices collapse, farmers retreat to subsistence production and low yield levels, which further deplete the basic nutrients in the soil.

One consequence of the highly coordinated development and dissemination of new mosaic-resistant varieties of cassava in the early 1990s was to flood the market and precipitate a dramatic price collapse in 1996. Fresh cassava does not store well and is not used for animal feed. Before the civil strife of the '70s, cassava was utilized in a starch factory in Lira and sold nationally and exported.

The grain legumes and cotton are expected to have growing internal and external markets. The dryland cereal-demand growth will depend upon the evolution of the demand for animal feed. This will depend upon the rapid growth of the demand for animal protein, especially poultry and milk, as incomes grow in urban areas. If farm groups can assure quantity and quality of traditional cereals, they will have a comparative advantage in producing cereals for feeds over imported cereals given the weight of transport costs in these low value exports.

The high-yielding sorghums, Seredo and Sekedo, face severe problems with storage pests. This reduces the producers' opportunity to store the sorghums until prices rise. Probably the most inexpensive short-term strategy for addressing this issue would be to facilitate the introduction of better-adapted storage facilities (e.g., air-tight silos and fumigation of storage facilities).

The sorghum, Epuripur, was bred at Serere for its qualities in breadmaking. If millers were encouraged to mix flours sorghum producers would benefit. Bread with up to 30% sorghum flour is not noticeably different to consumers. Uganda imports wheat so this would reduce foreign-currency requirements.

From 1983 to 1985, the import restrictions on importing grain led the government to use sorghum as the base for a new beer—Serena Beer and Crane Beer—in two of Uganda's government owned breweries. This utilization shift precipitated a two fold increase in sorghum production in the Kabale region. When these breweries were repossessed by their Asian owners in 1985, the owners reverted to using imported barley from Kenya.

What Needs to Be Done?

1. Simultaneously with technology development, domestic and international markets need to be evaluated to identify new markets and potential market constraints, especially quality control.
2. Improved infrastructure, especially rural roads, reduces input costs and increases the output prices received by farmers.
3. Public investments in storage and processing can be oriented to new markets. Some of this applied research is a higher-risk activity than the private sector is likely to undertake. This is especially important for sorghum since the new white sorghums open up a new range of products and processes potentially competitive with rice and wheat.
4. Improved market information will be critical. The IDEA project is championing a community-based system that groups farmers into community marketing groups as a mechanism to enable them to better exploit market opportunities. The beneficiary farmers are trained to maintain quality controls in the production and marketing process. The same program helps them establish market contacts and producer connections and researches export prospects.

Functioning of Agricultural Research in Semiarid Regions

The National Agricultural Research Organization was established in 1992 and includes nine research institutes focused on specific commodities. The principal objective of creating a centralized agricultural organization was to better coordinate the different national agricultural research programs, which had heretofore been distributed between different ministries.

By 1998, NARO had a staff of 1,057 employees: 724 core staff and 333 supported by outside-funded projects. The core staff included 187 scientists, 265 technicians, and 272 administrative support staff. Another 25 scientists were employed on outside projects, bringing the total number of research scientists to 212. Sixty-three of the 187 scientists on the core staff are trained to the Ph.D. level compared with 20 in 1992 (a 300% increase); 21% of the scientists on the core staff are women. This represents a significant increase in total staffing and training levels since NARO became operational in 1993.¹⁵

Unfortunately, 50% of the Ph.D. scientists are in just two of the 10 institutions: Namulonge Agricultural Research Institute (NAARI) and Kawanda Agricultural Research Institute (KARI). Of the Ph.D. trained scientists, only 8% are at the semiarid research institute (SAARI).

¹⁵ Unlike many other governmental organizations NARO consistently received the funds budgeted for it reflecting the government's general satisfaction with NARO.

One unintended consequence of the high levels of instability in Uganda's north since the 1970s was to restrict NARO's ability to conduct basic research, trials and demonstrations in the lower-rainfall semiarid zones. NARO's role is expected to expand as hostilities decrease and the government shifts to a new system of decentralized services. This is expected to increase the demand for semiarid agricultural technologies during the next decade. The principal source for acquiring this new information for the entire semiarid north is SAARI, the Serere Agricultural Research Institute, located at Soroti, 404 km northeast of Kampala.

SAARI was rebuilt with the help of a loan from IDA, the Agricultural Research and Training Project (ARTP) as well as the IDA-funded Cotton Sub-sector Development Project and various smaller grants from USAID and DFID. This funding in the early '90s enabled improvement of salaries, training, and the rehabilitation of lab and office facilities as well as line support for some operational expenses. Today the SAARI staff includes 142 employees consisting of 34 posts for scientists (27 are actually filled), 45 technicians (40 are filled), and 63 administrative support staff positions. Eight of the 27 scientists have Ph.D.s (30%), 18 have an M.Sc., and one has a B.Sc. The SAARI scientists are subdivided into five research programs: cotton, cereals (sorghum, finger millet, pearl millet), oil crops (groundnuts, sesame, sunflower), grain legumes (pigeon peas, cowpeas, grams), and animal production (cattle, goats, sheep, poultry) (Table 5).

Table 5. Breakdown of Scientists by Research Program and Level of Training for Five Major Research Programs and Specialized Units, Serere Agricultural Research Institute (SAARI), March 2000

Research Programs and Units	Ph.D.	M.Sc.	B.Sc.	Total	% Total
Programs					
Cereals	2	1	0	3	11
Cotton	4	6	0	10	37
Grain legumes	0	2	0	2	7
Oil crops	0	3	0	3	11
Animal production	2	3	0	5	18
Units					
Research extension liason unit	0	1	0	1	4
Soils science	0	1	0	1	4
Socio-economics	0	0	1	1	4
Cassava	0	1	0	1	4
Total	8	18	1	27	100

Source: SAARI, March 2000 in Oryokot, 2000.

In 1995, the Uganda government adopted a policy to devolve powers from the central government to the districts. Parallel to this process, the decision was made to divest extension services to NARO and to reduce the staff force of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF). For MAAIF this included a new structure and the reduction of its staff from approximately 1400 to 280 (MAAIF and MFPED 1998: 20). The goal of decentralization was to

bring planning and decision-making nearer to the people. In pursuance of this policy and constitutional provisions, the responsibility for technology transfer has been transferred to the district governments. The decentralization process calls for NARO to increase the proportion of research effort directed toward problem solving, on-farm adaptive research conducted off-station in collaboration with extension. To facilitate NARO's efforts to become more user friendly in dealing with farmers and other private sectors and NGO actors in the sector, the organization revised its administrative structure to include two Deputy Director Generals and divisions—one focused on research and the other on outreach. In the IGAD countries studied, only Uganda and Eritrea have combined their research and outreach activities in one agency.

The new structure consists of: (1) NAROSEC (the NARO Secretariat); (2) the Nine Research institutes; and (3) 12 ARDCs (Agricultural Research and Development Centers) representing each of the country's 12 major agroecological zones. Five of the ARDCs (Teso, Karamoja, Northern, West Nile, Cotton-Millet-Bananas) are located in areas with the very broad definition of semiarid referred to earlier. This implies that SAARI will have a much more important role in the future now that the violence has been reduced and its area of activities can be expanded.

NARO implements this decentralization process through the new system of agricultural research and development centers (ARDCs) and agricultural development centers (ADCs). ARDCs are based on agroecologies for a number of districts within a particular agroecological zone. Technologies developed from all NARO institutes relevant to a specific agroecological zone are tested and fine-tuned at a specific ARDC. The plan anticipates that ADCs will be established in each district for purposes of demonstration, teaching, seed multiplication and distribution, and information. This new system has major implications for agricultural extension and technology diffusion in the semi-arid north (Appendix 2).

The ARDC/ADC structure provides NARO (and particularly the SAARI) institute with a much stronger, direct linkage to the base communities serviced by state extension agents and the NGOs that work with them. The improved linkages will increase the demand for services and improve dissemination and feedback. The new system of ARDCs and ADCs enjoys high levels of political support in the north because it brings these isolated areas services which they value. The increased demand for technology services will push SAARI's staff, communication systems, and physical infrastructure to the limit.

Increased Diversity of Extension Actors

Historic Evolution of State Extension Activities

From 1983 to 1990 the government received a loan to improve agricultural extension in the north based on the Training and Visitation (T&V) model. The assessment of the T&V model nationally encouraged the government to adopt a new system of unified extension in 1993 which was again

supported by IDA through the Agricultural Extension Project (AEP). Since 1992, the main partner for NARO in technology development in Uganda's semiarid north has been the state extension service under the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF).

1987-92. Over this period there was very little agricultural research or extension activity in the north due to the persistent hostilities in the zone, although personnel still were posted to the zone. The same time period coincided with the rise of NGOs in Uganda as part of the reconstruction and relief efforts beginning in 1986. Early NGO programs in the north focused primarily on relief and reconstruction. As the NGOs orientation shifted from relief to development, they became more interested in acquiring seeds from the SAARI and extension services from MAAIF.

1992-2000. The formal process of rebuilding SAARI was facilitated with USAID and World Bank financing. As part of this process, the research staff organized field days at the station once a year to which policymakers, extension agents, farmer leaders, school teachers, and students from throughout the north came to observe new technologies.¹⁶ In addition to field days, the Serere researchers established an open-door policy to encourage local communities, schools, and policy makers to visit the facility. Throughout the 1990s there was a steady increase in the number of visitors to the center as well as demands by farmer groups, NGOs, community-based organizations, and individual farmers to purchase seed.

At the same time that the demand for new technologies in the semiarid areas was growing, the capacity of the state extension services in the north to respond to it decreased because of a substantial cut in their operational budgets after 1996. Especially important was the Ministry's inability to pay for routine inputs, such as Foundation seed, pesticides, implements, fuel, transportation, and per diems for the extension agents. This decreased budget spurred many NGOs, which had heretofore merely collaborated with the agricultural extension service, to take a more active role in financing these activities.

NGOs in the least-served areas (such as Karamoja) often hired their own agents. There were also many NGOs that invited research specialists from the Serere Institute (SAARI) to organize training seminars and demonstrations for both their extension agents and farmers. This type of government extension/NGO/research collaboration played a key role in the initial demonstration trials and popularization of Serere's new varieties of sorghum, finger millet, and cassava and in the on-farm trials, demonstration, and promotion of cowpea and pigeon pea. Specifically:

1. **Sorghum:** Collaboration with the government extension agents in Karamoja, Lango, and Teso regions with financial and extension support from the Church of Uganda, Oxfam, Lutheran World Federation, SOCADIDO, and World Learning in the Karamamja and Teso regions for

¹⁶ The number of people attending annual field days increased from about 100 in 1992 to 500 in 1996. After 1996, attendance was so large that it was no longer recorded. Although precise figures on area of origin of those attending do not exist, it appears that all the major farming systems were represented.

promoting the new sorghum varieties, Seredo and Sekedo.¹⁷ There was initial dissemination (free of charge) through the Catholic Church in Kidetok (Teso) of the Epuripura sorghum variety that was developed for bread making. SAARI provided the Foundation seed but no demonstrations.

2. **Finger Millet:** Collaboration with government extension agents and the NGOs (Church of Uganda, Oxfam, SOCADIDO, SDDP, and World Learning) with financial support from the IDA-funded government project NURP (Northern Uganda Reconstruction Program) in distributing free the initial Foundation seed for the high-yielding, drought-tolerant, and blast-resistant finger millet PESE 1.¹⁸
3. **Pigeon Pea:** Strong collaboration between SAARI, ICRISAT, SG2000, World Vision, and extension to organize on-farm trials (1995-97) and then the provision of seed and pesticides for farmers after 1996 in the Lira and Apac districts of the north.
4. **Cowpea:** Collaboration with the state extension service working with the Church of Uganda in the Teso region conducting on-farm trials to perfect the technology (1998) for Large White H and I and the demonstrations to promote the technology (1999).
5. **Groundnuts:** Collaboration with the government service, with financing from IDA, Church of Uganda, and SOCADIDO to (a) conduct initial demonstration trials of IGOLA1 (1994-95), and (b) carry out the initial distribution of Foundation seed (1996).
6. **Cassava:** National-level collaboration of government extension, NGOs and CBOs, with strong political support for multiplication and distribution of the mosaic-resistant materials (1988-96).

The same time period (1992-2000) witnessed a gradual growth in the number of private-sector suppliers of the most important agricultural inputs (pesticides, animal-traction equipment, hand hoes) that farmers use.¹⁹ The private-sector supply networks became important in provisioning

¹⁷ Researchers from the Institute conducted demonstrations, provided Foundation seed (which was then multiplied by farmer groups supervised by the individual NGOs), and trained the government and NGO extension agents. The NGOs in turn provided feedback to the Institute about the performance and the acceptability of the new cultivar.

¹⁸ The NGOs, often on advice of the state extension agents working in their zones, purchased Foundation seed from NARO, which they distributed to farm groups. The seed was then multiplied through group-organized community seed projects and private entrepreneurs. A high percentage of the seed produced by these projects was multiplied by private individuals who then sold it in their communities. In contrast, the government NURP project contracted directly with SAARI to multiply the finger millet PESE 1, which they supplied (40 metric tons of seed) through government extension to the farmers in the northern region.

¹⁹ As mentioned previously without inorganic fertilizers these yield gains will be smaller and not sustainable as farmers continue to deplete their basic soil nutrients, N and P. Moreover, the water retention techniques will be essential to reduce the riskiness of soil fertility improvements in the semiarid regions.

some of the critical inputs, especially seed from the newly privatized Uganda Seeds Ltd. stockists and pesticides from private vendors. Unfortunately, fertilizer is not distributed through these networks.

In 1998, the government of Uganda embarked on the massive reorganization of state extension services under NARO previously discussed. This reorganization was a response to the constitutional provision for full decentralization of all state services. The same model attempted to make the organization better able to coordinate research and extension with the increased diversity of CBO, NGO (national and international), and private businesses active in the agricultural sector. The new model for extension calls for three agricultural extension officers posted in each sub-county (one for crops, one for livestock, and one for fisheries).

With decentralized extension, the key player is the local district administrator. The district, through its Planning Committee, sets up a prioritized agenda for its agricultural development. Hence, the success of an agricultural extension plan is largely dependent on district priorities. NARO is required to link up directly with the extension services in the district—both government and private sector (NGO).

Equity and Gender Issues

Parallel to the decentralization process, the government (with support from the World Bank and other donors) embarked on a process of reflection and research on poverty. The Uganda government was one of the first countries in Africa to make poverty alleviation the central focus of its entire World Bank country assistance strategy and to actively involve NGOs, such as OxFam, in researching and defining the strategy. The initial product was the Poverty Eradication Action Plan (PEAP) which was formally ratified in 1996. With input from the Highly Indebted Poor Countries Initiative (HIPC), Uganda has also established the Poverty Action Fund as a vehicle for poverty-focused social interventions and has maintained the poverty assessment unit (with its mixed NGO, government, donor technical, and administrative structure) as a tool for monitoring on some of the identified welfare indicators (Table 6).

Note that on sandy soils water retention techniques focus on increasing organic matter levels. On clay soils runoff needs to be reduced.

Table 6. Selected Welfare Indicators By Region

Indicator	Central (%)	East (%)	North(%)	West* (%)	Uganda (%)
Average number of meals per day	2	2	2	2	2
Households purchasing meat or fish at least once a week	67	42	48	45	52
Households with adequate supply of milk for children below 5 years	27	21	12	10	19
Households that can afford to buy salt	95	90	61	66	79
Households with everyone having at least two sets of clothes	90	87	77	68	82
Households whose heads have at least one pair of shoes	83	76	50	46	65
Households living in thatched houses	28	60	89	42	50
Households living in own houses	71	86	88	90	79
Household with any means of transport	38	40	34	37	37
Households that could afford the care they wanted the last time someone in the household was ill	69	63	35	53	56

* Indicators of “poor” in the western region—particularly for diet, clothing, and affordable health care—are surprising for an area of relatively high income levels (Uganda, 1999. Background to the Budget).

Source: Uganda National Household Survey, 1997. Statistics Dept. MFPED, Entebbe.

Recent studies associated with the preparation of the second phase of the Northern Uganda Reconstruction Project estimate that women farmers constitute up to 70% of the total agricultural labor force (COWI, 1998). They are responsible for 70-89% of the food crops, 50% of the cash crops, and all food processing. A consequence of the severe social disruptions that have characterized the region in the last 20 years appears to have been to increase women’s roles as well as household-level dependence on women’s cash and subsistence income throughout the region.

There is general consensus within NARO, and the Serere Research Institute that gender issues are critical to NARO’s ability to carry out their mandate for technology development and dissemination since:

1. Women have historically dominated agricultural production throughout the semiarid region (Box 2);
2. Women farmers tend to be better organized than men into formal, registered Community Based Organizations (CBOs) that facilitate communication between NARO and the villages for technology tests and dissemination.

Box 2. Regional Variation of Female Participation in Semiarid Agriculture

In the Soroti, Katakwi, Kumi and Pallisa districts women are solely responsible for seed-bed preparation, weeding, and planting of food crops. Before the cattle-rustling period (late '80s), the use of animal traction was widespread and the area cultivated was larger.

In Apac, Lira, Gulu, and Kitgum, both men and women work on agricultural production in groups organized in rotation, and at times in return for local brewing or for processing harvested crops. In Kotido and Moroti districts, cattle-raising is done by men while women handle crop production.

In the West Nile districts of Adjumani, Moyo, Arua, and Nebbi, food crop production is done primarily by women while the production of cash crops—particularly tobacco, cotton, and coffee—are left to men. The loss of the cash-crop economy to the men has reportedly undermined women's former control of the overall household economy and lowered their status.

Despite their significant contribution in agricultural production, the predominance of the communal ownership of land in the semiarid districts has generally excluded women from decisions on land utilization. Other constraints that impact on women's ability to grow crops profitably include their limited access to capital markets and market information. Probably the single most important constraint which impacts on each of the others—because it impedes the flow of information to women that would otherwise open up new economic opportunities—is the semiarid districts' extremely high rates of female illiteracy (COWI, 1999a, b, c, d).

Senior researchers at the Serere Institute argued that their active involvement of women stakeholders at every stage of their three stage technology development and extension process (Stage 1: Needs Assessment; Stage 2: Applied Research; Stage 3: Introduction and Dissemination) was an important factor in their ability to get village-level acceptance. The same high levels of involvement have made it easier to get stakeholder acceptance of technologies once they were developed. One of the most recent examples of this is the rapid, spontaneous diffusion of Igola 1 groundnuts in the Teso and northern regions even before their official release.

One of the best documented experiences of two-way communication of a national agricultural research institute in the semiarid Horn with a women's group is the extensive involvement of SAARI with the BUWOSA (Bukedea Women Strugglers Association), which received a \$250,000 grant from the African Development Foundation (ADF-USA) in 1994. The initial start-up grant,

facilitated by a researcher at NARO, provided funds for purchase of animal-traction animals and equipment, inputs, a truck, an oil mill, and administrative office building.

During the first year, NARO provided the group with technical advice and sold them Foundation seed. The animal-traction animals were owned by groups of four women who continue to share ownership of the oxen and equipment. Although the group has never been the object of a socioeconomic study, our interviews with researchers, extension agents, and the Minister of Gender, Labor and Social Development indicate that these interventions have had impacts on 840 impoverished women, their households, and the Teso region.. This Teso region has been one of the areas worst-ravaged by the insurgency and cattle-rustling.

In turn, the women's group provided NARO with on-farm trials that permitted them to fine-tune the technologies and agronomic practices associated with many of their new cultivars. The same collaboration appears to be a major factor responsible for the accelerated rates of technology diffusion within the Teso region for most of the new NARO-developed cultivars and agronomic practices (see Table 2).

Another women's group, formed in 1996 to address food security and poverty concerns in Soroti district in the semiarid north, was the Amora-Ican Women's Group. From 1996 to 1998, this group worked with the government's agricultural extension service in Soroti to obtain technical advice on agricultural production for their individual food crops. This group was very important in diffusing the new peanut cultivar, Igola 1 and cuttings for the mosaic resistant cassava cultivars. They initially received the seed, produced and distributed it among themselves, and then began selling the improved cultivars to their neighbors.

In 1999, a private-sector cotton ginner approached the Amora-Ican Women's Group about subcontracting with him for commercial cotton production. This contract stipulated that he would provide them with inputs (i.e., seed and pesticides) and would guarantee a market for their cotton under the system overseen by the parastatal cotton development organization (CDO). The short-term impact on technology diffusion was increased pesticide application and agronomic practices. This resulted in higher yields (650 kg/ha vs. 400-500 kg/ha for the region as a whole in that year (from personal communication with the group, February 2000).

In addition to these success stories, there were a number of cases where women's groups failed to flourish and/or folded once donor funding stopped. These projects were typically projects that had been designed in a top-down fashion with little ownership by women or local leaders. These design flaws were especially noticeable in a high percentage of the first generation micro-credit schemes associated with the Entandikwa movement (under the Ministry of Gender, Labor and Social Development) which became mired in local politics.

To summarize, SAAR's extensive investment with women's groups accelerated diffusion and reduced the costs of on farm trials, demonstrations, and dissemination of new technologies. One

advantage of SAARI working with established NGO groups was that it enabled the Institute to avoid the cost of investing time and material in partnership with non-sustainable NGO groups. The need to work through NGOs was especially important in post-conflict areas, such as the Western Nile and Karamoja, where NGOs have played a key role in disaster relief and rehabilitation.

NARO's experience with implementing the national government 30% quota for female participation in every aspect of the research program facilitated the administrator's task of insuring women's participation. One key to NARO's future success is to continue to strengthen the number and professional qualifications of the women within the organization. About one-third of the NARO women researchers are newly recruited M.S. and Ph.D.s. These women constitute a resource that needs to be supported and mentored to provide the organization with dynamic leadership into the next millennium. To develop as researchers and NARO leaders, these female researchers need to conduct research and publish. More professional women need to be invited to professional meetings not just to gender-training workshops.

Policy Support to Agriculture

During the past decade in Uganda a profound re-orientation of the economy took place in which incentives to farmers were improved markedly and substantial progress was made toward privatization and decentralization of economic life (World Bank, 1998, p. iii). A number of important policy issues still under debate are directly relevant to the issues identified here for intensifying agriculture in semiarid regions (Table 7).

Decentralization

Uganda is committed to decentralization, but substantial effort is required to put in place the three essential elements for political legitimacy, i.e., adequate funding plus analytical and administrative capacity (World Bank 1998, p.18). Especially important for technology diffusion is the current reorganization of agricultural research and extension. NARO has spent the last eight years (1992-2000) engaged in a painful process of rebuilding its human capacity and physical infrastructure in the semiarid north. Although the new decentralized model presents a host of new opportunities for accelerating diffusion, there are problems.

One significant policy issue for agriculture derives from the inherent tension between local autonomy in decision-making and the centrally determined priorities of the plan for modernizing

agriculture. This same tension may make it more difficult to coordinate interventions, such as rural roads and agricultural technology development.²⁰

A second issue, most clearly perceived as a threat by NARO researchers, is that reorganization will increase the short-term cost of administering research programs while simultaneously decreasing the budget stability of the research units. The proposed budgetary formula (mixed district and national funding) is not clear. This budget problem is further exacerbated by the relative stagnation and decline in the line-government support to agriculture. In 1997 the national expenditure on agriculture research (at 0.6% of agricultural GDP) was approximately the average across Sub-Saharan Africa and less than one-fourth of the proportion spent on agricultural research in industrial countries. National expenditure on agricultural extension (at about 0.35% of agricultural GDP in 1997) was only one-third as high as the average for Sub-Saharan Africa. From 1992-93 to 1997-98, government contributions to agriculture decreased from 1.3% to 0.8% while Defense Affairs and Services increased from 15 to almost 24% before declining to 21% and that of Public Order and Safety Affairs increased from 4.5% to 11%. Between 1988 and 1996, donor contributions to agriculture fell from 26% to 0.5% (Republic of Uganda Statistical Abstract, 1999, pp. 45, 51).

Privatization

Probably the single most important constraint to the diffusion of new technology into Uganda's semiarid areas has been the inadequate supply of high-quality, improved seed. One major policy change affecting technology diffusion was the decision to privatize Uganda Seeds Ltd. This leaves a vacuum in the production of quality seed for the smaller markets and for the cultivars of the semiarid zone. Uganda already has laws concerning breeder's rights that protect NARO but not the individual scientist. The same lack of patent rights and or licenses for private companies appears to be a major constraint to the accelerated production of some of the new animal-traction technology that NARO has developed.

Fertilizer Policy

One extremely important policy omission is the lack of a government fertilizer policy. NAROs lack of research on this topic is a direct reflection of this lack of a national strategy. NARO could help to galvanize and direct this type of macro policy reflection by strengthening its internal

²⁰ Feeder-road programs in rural areas are likely to be most productive when associated with agricultural programs designed to increase farm productivity. By the same token, agricultural programs are most effective where transportation linkages have been established.

Table 7. Key Policy Issues Affecting Technology Diffusion

Factors contributing to or detracting from diffusion of new technologies	Key Policy Issues	Proposed policy changes and/or considerations in macro policy debates
RESEARCH: NARO/SAARI have developed strong research capacity and technology products over the last eight years that are being diffused throughout the semiarid north.	Current plans for decentralization call for merging research with extension at district level. These plans will increase short-term costs of administering research programs and decrease budget stability of research units.	Decentralization
NEW TECHNOLOGIES: NARO/SAARI research programs effective in disseminating new technologies but have tended to emphasize cultivar-alone strategies with comparatively less interest in improved agronomic practices.	Government failed to appreciate critical role of soil-fertility issues as a constraint to increased production.	National Fertilizer Policy Poverty Action Plan Food Security Plan
INPUTS: Insufficient supply of improved seed constrains diffusion of new crop cultivars.	Private-sector markets constrained by lack of clear policies on breeders' rights. Uganda Seed Co. constrained in varieties and amount of seed it can produce.	Breeders' (technology) rights Privatize Uganda Seed Co. Stimulate development of more private seed companies
Insufficient capacity to produce mechanical planters, weeders, and ox carts is a major constraint on their diffusion.	Insufficient capacity for manufacture of animal-traction equipment	Privatization (manufacture) technology rights
Farmer use of purchased inputs importantly constrained by price and accessibility for pesticides, fertilizer, and seed.	High price of petroleum. Agenda for rural roads. Some regulations on private-sector suppliers that reduce their profit margins are not realistic.	Petroleum tax. Agenda for rural roads. Regulations controlling agriculture. Commerce.
OUTPUT MARKETS: Low producer prices and price instability associated with crops, especially major food crops, affect farmer willingness and capacity to invest in higher-yielding technology.	High price of fuel reduces producer prices and export potential of semiarid crops. Inadequate roads.	Reduce petroleum tax Agenda for rural roads
Adequacy or inadequacy of road infrastructure has profound impact on markets and on effectiveness of research extension processes.	National and regional planning to develop rural, primary, and secondary roads needs to consider technology potential of zones for particular higher-yielding technology.	Infrastructure development policies (roads)
Sorghum production faces a number of important production, storage, and marketing constraints that impede technology diffusion and increase food insecurity in the semiarid north.	Uganda's Food Security and Poverty Action Plan gives insufficient attention to sorghum production, storage, and marketing issues and how they affect food security in the semiarid zones.	Food Security Plan Poverty Action Plan
EQUITY AND GENDER: Diffusion of new, higher-yielding varieties in the semiarid north has been associated in some areas with increased incomes, nutritional well-being, and living standards.	Technical and socio-economic staff familiar with constraints and opportunities of new, higher-yielding crop technologies for the north need to be involved in revising the Poverty Action Plan.	Poverty Action Plan
NARO/SAARI's targeting of technology development and diffusion through women's groups has accelerated technology diffusion and impact, reduced poverty, and increased food security in some areas. This impact greatest when given to groups having access to complementary resources like credit and training provided through an NGO.	Policymakers associated with the Gender Action Plan have insufficient data to monitor the impact of technology diffusion to women vs. other types of development investment in the semiarid north.	Gender Action Plan Food Security Plan Poverty Action Plan

research programs on soil fertility. NARO would benefit from some coordinated support from other agencies such as the International Fertilizer Development Center (IFDC), SG 2000, and the ASARECA networks.

Incentives to the Private Sector

The government is in the process of reviewing a wide variety of regulations that increase the costs of operating businesses in Uganda. A number of these regulations affect agricultural input stockists directly, such as restrictions on selling both animal- and plant-related chemicals in the same stores.

Agenda for Rural Roads

The largest single investment category in the government's Medium Term Plan for Modernization of Agriculture (PMA) are the investments in feeder roads over the first five years of the program (US \$377 million). This investment involves upgrading and rehabilitating existing ones and maintaining feeder roads so as to realize the reductions in transportation costs that would reduce input costs and increase the share of output price paid to farmers (World Bank, 1998, p. vi).

Government NGO Policies

Uganda has encouraged NGOs to work as active development partners in the rural areas. The strong record of NARO in research, extension, and NGO collaboration in the development and dissemination of new technologies was discussed earlier in this report. One goal of the new model for decentralized extension has been to strengthen district-level collaborative planning between government research and extension, NGOs, and the private sector. Recent changes that require NGOs to register annually are a source of concern among NGOs. These policies need to be reviewed to examine how they may decrease the willingness and effectiveness of NGOs to support technology diffusion in the semiarid zones where their services were critical for the success of government research and extension activities in the '90s.

The Gender Action Plan

Since 1986, the Uganda government has put gender issues as a principal focus of public policy. Especially important has been the government's support for a National Gender Policy and Gender Plan of Action (1997). This plan was formulated in a highly participatory fashion with input from civil society as well as from the major technical ministries. Many of the stipulations of this policy—most notably the requirement that at least 30% of the beneficiaries of all programs be women—has helped strengthen the commitment and capacity of NARO leaders to target women farmers and to hire and train women research and extension specialists. The same gender quotas and commitment appear to have accelerated the rate of technology diffusion and poverty impact of NARO programs.

Conclusions

NARO was been very successful in the '90s in getting new cultivars onto farmers' fields all over the country. With cassava, there was an effective response to a devastating pest. With cotton, there was a rebuilding of the industry and support for an effective parastatal. For maize, there were excellent new cultivars and expanding markets. For finger millet, peanuts, and cowpeas, SAARI researchers worked effectively with the NGOs, especially in seed production and in introducing new cultivars. The NGOs had good community ties from their relief activities and wanted to be more engaged in agricultural production.

Quality seed production is difficult to maintain especially with rapidly increasing demand for the new cultivars. The parastatal seed company is moving toward privatization and showing less interest in semiarid crops. A chronic problem of community seed production is adequate quality control. Underpricing the seed can reduce incentives of producers and discourage the emergence of a private sector. Public funds for orphan crops in the parastatal and policies to encourage the emergence of private seed companies for small markets both seem appropriate priorities for public support of the semiarid zones.

Despite Ugandan mythology about fertile soils, the principal constraint to increasing yields in the semiarid region is increasingly the depletion of the principal soil nutrients. Inorganic fertilizers are expensive with high transportation costs and are unlikely to be effective or profitable without simultaneous introduction of water-retention technologies. These combined treatments of water retention/soil fertility are presently the critical applied-research requirements. Organic fertilizers and other soil-fertility improving practices will often need to be combined with inorganic fertilizers, but they are not substitutes. Even with high transportation costs, the cheapest fertilization method per unit of N and P is generally inorganic fertilizers.

During the Idi Amin government (1971-79) and the second Obote period (1980-85), and until Museveni could control disruptions from the northern rebels (the 1987-91 period), agricultural research and development were thoroughly disrupted in most of Uganda, especially in the semiarid regions. Since 1992 the research funds and new staff were coming back to the research station at Serere. This has enabled the release of a series of new cultivars and associated agronomic recommendations. These now need to be combined with improved functioning of the input (seed, fertilizer, and credit) and product markets and with more applied research and diffusion of the combined water retention/soil-fertility innovations.

The improved functioning of the input markets (seed and fertilizers) is critical to the intensification of production in semiarid regions. As with pigeon peas in Kenya, the simultaneous investment in identifying and facilitating new markets simultaneously with the introduction of new technologies will be the necessary strategy. Unless new markets are identified and developed, staple food

markets tend to have price collapses when rainfall is good or new technology is introduced. Therefore, systematic identification of new markets is as important as improving the functioning of the input markets.

It has been emphasized that the grain legumes have substantial potential for new export markets. However, the traditional dryland cereals also have potential for rapid expansion with the impending shifts in human diets to increasing consumption of animal products. In many other developing countries, demand growth for feed grains, especially for poultry and dairy production, have been so rapid that these countries have had to substantially increase their feed grain imports.

Uganda has had impressive performance in its collaboration with NGOs and in its gender policies. Now it is rebuilding its extension in the semiarid regions. In the insecurity period from Ida Amin to 1992, extension became ineffective due to its association with the central government. A more rapid introduction of inorganic fertilizers, improved seed of new cultivars, and water-harvesting techniques would help both male and female farmers. The NGOs can facilitate this process as they build up their agricultural expertise and recognize the fundamental importance of increasing soil fertility.

More emphasis in the budget on agriculture and less on defense and public order would also be expected to have positive effects on increasing rural incomes and reducing food costs. Sufficient investment in public goods is necessary to support agriculture (research, extension, infrastructure) in order to complement privatization and to enable rapid agricultural output growth.

There is an initial tendency of the private sector to be more interested in the higher-rainfall regions. With more water and increased soil fertility, the semiarid zones have a comparative advantage over the higher-rainfall regions because of reduced disease incidence and longer hours of sunlight. California, Israel, and Australia discovered this sometime ago.

Appendix I: SWOT Analysis of NARO

Strengths: Organizational Structure and Capacity

NARO has developed a research strategy and mid-term plan. This set the direction for research, management including internal functions, institutional capacity building, rehabilitation of infrastructure, and human resource development. The autonomous status of NARO provided for in the Statute facilitates their activities.

An organizational performance assessment (OPA) mechanism has been instituted and put in place to allow for self-evaluation. This should make possible the identification of organizational weaknesses and mechanisms for responding to these problems. This must be regularly undertaken and its results seriously addressed.

Some weaknesses in NARO's organizational structure and capacity building can be identified that may affect the full attainment of its stated goals. While NARO has a mandate to develop technologies to increase agricultural productivity, the linkage between it and technology dissemination/transfer structures through the Research Extension Linkage Unit (RELU) are weak. Its technologies may not be able to make as much of the desired impact. This is set to change with the establishment of the ARDCs and ADCs. Adequate linkage mechanisms must be built in the ARDCs for effective transfer processes.

In the first five years of NARO its mid-term plan was funded largely from Uganda Government sources through a World Bank loan and some donor support. As a public research system, it has remained dependent on this government and donor support. Given that government support to the entire agriculture sector is only about 0.8% of GDP, there is need for the organization to diversify its sources of funding by charging for some of its technologies and working closely with the emerging private sector.

There are no clear career tracks in the organizational structure and this may affect capacity building and serve as a disincentive. Fortunately NARO has put in place an internal operational performance assessment (OPA) mechanism.

Appendix I, Table A-1. An Assessment and Critical Analysis of NARO's Research Organizational Structure and Mode of Operation.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
Organizational structure and capacity building	<ul style="list-style-type: none"> • Has a National Agricultural Research Strategy and plan • Strong Board /Secretariat and research management • Good institutional infrastructure • Well trained man power • Substantial autonomy/independence (NARO statute) • Good management of internal functions 	<ul style="list-style-type: none"> • 40% districts in semiarid areas but only 14% NARO scientists • Inadequate research-extension linkages dissemination/ transfer structures • Inadequate socio-economic and processing specialists • Weak public relations • Unclear career track • Uneven distribution of scientists between disciplines and between institutes • Uneven distribution of women scientists 	<ul style="list-style-type: none"> • Government good will and support • Decentralization to allow closer linkage with clients • High proportion of young trained scientists • Responsibility for technology dissemination • PMA/VISION 2025 emphasis on a strong research structure 	<ul style="list-style-type: none"> • Poor/low remuneration • High public/Government expectations. • Government policy of liberalization. • Thin spread on the ground • Political instability in the north • Inadequate staffing • Increased responsibilities with decentralization
Mode of operation	<ul style="list-style-type: none"> • Client orientation in priority setting and annual reviews • Good linkage with national institutions, IARCs, Regional and International Networks 	<ul style="list-style-type: none"> • Compartmentalization of research by commodity • Dependence on government/donor financial support • Some crop program are inadequately funded due to lack of complementary support • No reward system 	<ul style="list-style-type: none"> • Good linkage with NGOs • Rationalization of staff deployment • Privatization central research to private sector. 	<ul style="list-style-type: none"> • Thin spread on the ground • Narrow resource/funding influence.

Weaknesses: Organizational Structure and Capacity

One of the most glaring weaknesses is that NARO's research infrastructure and personnel are heavily concentrated in the higher rainfall zones. Although 18 of the country's 45 districts (40% of the total) are located in agroecological zones that are classified as semi arid, 86% of the research scientists and 8 of the 9 research institutes (90% of the research infrastructure) are located in the higher rainfall zones.

Opportunities: Organizational Structure and Capacity Building

NARO enjoys strong government goodwill and support. This is illustrated by receipt of more than 90% of its approved annual budget for its activities. The government's Plan for Modernization of Agriculture (PMA) and Vision 2025, which define the country's development framework, both emphasize the need for a strong research structure.

The responsibility for technology dissemination that has been given to NARO means that it can now plan for the entire process of technology development and dissemination. In this arrangement the decentralized government system allows NARO to establish a closer linkage with different local governments and the stakeholders in the sector at this level. NARO must exploit this to source for additional funds for its activities including charging for its services.

Threats: Organizational Structure and Capacity Building

The government/public has very high expectations in NARO given its good performance since its formation. The organization must therefore guard against assuming responsibility beyond its capacity, especially if these responsibilities are not matched with funds. This may happen in the current added responsibility of taking a leadership role in technology dissemination. Failure to deliver and meet the public's expectations could affect the current goodwill and funding. NARO's leadership must carefully guard against this. A public relations capability is needed to manage the public's expectations.

The expanded role of NARO to include technology dissemination and the de-centralized research system to the ARDCs without provision of matching manpower requirements has implications on staff deployment. A danger of inadequate staffing becoming spread thin on the ground is very real and careful planning is called for. In addition, the low salary packages NARO offers are not enough incentives for the additional responsibilities. This must be reviewed. The threat of over extending services is especially serious for SAARI given its wider area of coverage under the new system (40% of the country's districts).

The government's policy of liberalization of the economy enables free play of market forces. Increased productivity through new technology introduction may result in marketing problems. This is already being felt on the ground in the case of cassava. Increased production as a result of

adoption of high yielding varieties resistant to Cassava Mosaic Virus, has resulted in a glut in the market with resulting low prices for farmers.

NARO needs to increase the capability of the Food Science Research Institute (FOSRI) to conduct product development research. Structures for collaboration with national, regional and international research institutions in this endeavor are in place and must be exploited.

Strengths: Mode of Operation

The NARO statute stipulates that research institutes develop short and long term research programs based on the identified production, policy, marketing, processing and utilization constraints in their mandates. This mode of operation requires that a constraint/problem be identified. Due to limits set by resources, NARO involves its clients and stakeholders in the agricultural sector, in priority setting. Client orientation is an important factor and is NARO's strength in developing appropriate technologies.

One strength of using commodity programs as a basis for research is that the institutional model facilitates good linkages with national, regional and international institutions conducting research in similar commodities. These linkages have resulted in better efficiency in the utilization of research resources. The development and release of improved groundnuts and cassava varieties in a short period of time for example, has occurred through this linkage with ICRISAT and IITA respectively.

Weaknesses: Mode of Operation

A major weakness in the current NARO structure is that the current organization of research under commodity programs results in compartmentalization. This in turn restricts the agency's ability to handle production system based constraints such as soil productivity or soil water conservation that cannot be handled effectively by focusing on only one crop. On issues falling between commodities this mode of operation is not efficient in utilization of resource; it also reduces the synergism that would result from bringing together the expertise of different scientists who are not in the same commodity program.

A project rather than a program mode of operation is recommended. Programs often lead to complacency as researchers assume that there will always be a cereals program. Whereas projects, such as to attain Striga resistance, clearly have a beginning and an end. Researchers in the project system and the overall project performance can be more easily evaluated for progress towards their specific goal.

To facilitate a shift to projects NARO needs to establish a research fund. This fund would enable a competitive bidding process among NARO and other scientists to achieve certain specified goals.

In the current set up, funds come to the program and may not necessarily be spent on the project's experiments as budgeted.

Opportunities: Mode of Operation

The current mode of operation lends itself well to the utilization of the private sector for performing certain activities under contract. For example some research in the cotton program, in which the private sector has interest, can be privatized and allow for better deployment of staff in other areas that may not have comparable private sector interest.

Institutes have strong linkages with non-governmental organizations (NGOs) at the program level. This linkage may be through joint participation at workshops or conducting on-farm trials. This linkage provides opportunities for evaluation of technologies by farmer groups and communities in which these NGOs operate. In certain situations, this arrangement has been even more effective than the public extension service for technology transfer.

Threats: Mode of Operation

Due to disproportionate distribution of scientists in some disciplines, and the compartmentalization of research in commodity programs, there is a thin spread of scientists on the ground in some programs and even institutes. To improve on the funding base, these poorly funded programs are encouraged to search for funding. This has to be done without losing track of the organization's and institute's objectives. Undue donor influence may cause a program to deviate from the set objectives and has to be watched.

Appendix II: SWOT Analysis of the New Extension System

Strengths

1. One of the principal strengths of the new arrangement of extension and research personnel is that it enables agricultural researchers to link up directly with the extension personnel at the district level. Previously, new technologies were routed through the MAAIF headquarters. This increased the bureaucracy and delayed the process of technology transfer.
2. The new system makes it easier for the district to hire and fire extension personnel. This provides for more effective supervision of the staff and ensures efficiency and effectiveness.
3. There are great hopes that the new system will also make it easier for researchers to receive direct feedback on the performance of technology at the farm level. The new system should also facilitate NARO's participation in the conception and implementation of the district agricultural plan.
4. The new system should also increase the confidence of NGO and private-sector participants in the sector to collaborate with NARO and for NARO to collaborate with them.

Weaknesses

1. The districts normally have a wide range of development priorities and they allocate their resources accordingly. Some districts may not receive adequate resources for effective performance.
2. Researchers are not trained in extension. This system, however, requires that researchers understand some basic principles of extension. Some amount of training will be necessary, especially for staff at the management level.
3. NARO cannot supervise extension personnel of the districts; neither can NARO control the agriculture budgets of the districts. This will make the technology-transfer process dependent on when funds or staff are available. The volume of technologies to be disseminated will also vary with the amounts of funds the district can find rather than what technologies are required in the district. The districts are expected to contribute funds to the operation of the ADCs. This may prove difficult for some districts.

Opportunities

1. Technologies are brought closer to the farmers. Farmers will have more opportunity to provide feedback and to dialogue with researchers.

2. The private sector, especially input dealers, can take advantage of the performance of the ARDCs and ADCs to market their products. This will also enable them to demonstrate the usefulness of their inputs.
3. Operational costs of NGO and other extension staff will be greatly reduced since services are closer to their areas of operation.
4. Technology-adoption will be hastened. Demonstrations, inputs, information, training opportunities, and on-the-job learning will be easily accessible.

Threats

1. The establishment of ARDC and ADCs and increased requirements for extension personnel translates into increased budgetary provisions for both the central government and districts. NARO currently receives donor funds and is largely dependent upon these. Part of the decentralization process is that the districts will have to find funding for many of their activities. They may be able to tap donors but they have no experience in doing this. A system should, therefore, be put in place that will make the decentralization model financially sustainable.
2. NARO will need to subcontract some of its activities such as specialized training, seed multiplication and information documentation and dissemination. This requires budgetary provisions.

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Hon. Peter Teko Lokeres, Minister of State for Karamoja Affairs, Office of the Prime Minister

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