Part I:
Low-Resource Agriculture and Development Assistance

Chapter 3
The Status of
Low-Resource Agriculture

CONTENTS

Boxes

Figure

Tables

Chapter 3

The Status of Low-Resource Agriculture

HIGHLIGHTS

- Low-resource agriculture is practiced by a diverse group of African farmers, herders, and fishers, is based primarily on the use of local resources, but may make modest use of external inputs, including information and technology.
- Low-resource agriculture predominates throughout Sub-Saharan Africa. It produces the majority of the region's food, involves and provides income for the majority of people, helps buffer against famine, and contributes to national economies by producing agricultural products for domestic use and export.
- Low-resource agriculture is no longer able to meet the needs of Africa's growing population. Declines in per capita food production and agricultural income, widespread malnutrition, and natural resource degradation are signs of its decreasing capability and reasons for concern about the future.
- Increasing numbers of Africans will depend on low-resource agriculture for food and livelihood in the coming decades. Thus, it is increasingly important to improve low-resource agricultural systems so they are better able to help meet Africa's food security and agricultural development needs.

AFRICAN AGRICULTURE: RESOURCEFUL WITH FEW RESOURCES

Africa's hallmark is its diversity. Its vast cultural diversity is manifest in nearly 800 distinct ethnic groups, which account for about one-third of the world's languages (23). The 45 countries of Sub-Saharan Africa show a wide array of political and economic systems, including numerous systems of tribal and modern law. The region also has wide ecological diversity—ranging from desert to savannah to rainforest—and broad soil and climate variations that can change over short distances. This diversity is mirrored in the nature of African agriculture. Having evolved under these differing biophysical and cultural influences, African agriculture encompasses a complex array of crop and livestock production systems.

Clearly, then, it is risky to generalize about African-agriculture. There is no such thing as a "typical" African farm. Some common elements, however, can be identified. One consistent aspect of African agriculture is its prominent position in African economies (table 3-1). Agriculture employs about three-quarters of Sub-Saharan Africa's labor force and accounts for about one-third the region's gross domestic product. Also, about one-half of the countries in the region derive at least 40 percent of their export earnings from agricultural products. Further, despite major increases of food imports, particularly grains and dairy products, the region still produces most of its own food—at least 80 percent of its cereals, 95 percent of

Table 3-1 .—Importance of Agriculture to African Economies

Country	Population in millions (1985)	Labor force in agriculture as % (% in 1980)	Agriculture % of GDP[a] (1985)	Agricultural exports as % of total exports (1983)
Angola .,	8.8	74	(30-50)	(4)
Benin	4.0	70	48	(73)
Botswana.	(1.1)	70	6(10-29)	(15)
Burkina Faso	7.9	87	45	(83)
Burundi	4.7	93	61	(98)
Cameroon	10.2	70	21(30-50)	(39)
Cape Verde	(0.3)	(52)	—	(19)
Central African Republic (CAR).	2.6	72	39	(51)
Chad.	5.0	83	(30-50)	(63)
Comoros	(0.4)	(83)	(30-50)	(83)
Congo	1.9	62	8(10-29)	(1)
Djibouti	(0.3)	—	—	—
Equatorial Guinea	(0.4)	(66)	—	—
Ethiopia	42.3	80	44	(88)
Gabon	(1.1)	(75)	(<10)	—
Gambia	(0.6)	(84)	(10-29)	(54)
Ghana	12.7	56	41(>50)	(42)
Guinea	6.2	81	40	(9)
Guinea-Bissau	(0.8)	(82)	(30-50)	(43)
Ivory Coast	10.1	65	36	(59)
Kenya	20.4	81	31	(57)
Lesotho	1.5	86	(10-29)	(26)
Liberia	2.2	74	37	(18)
Madagascar.	10.2	81	42	(87)
Malawi	7.0	83	38	(86)
Mali	7.5	86	50(10-29)	(77)
Mauritania	1.7	69	29	(14)
Mauritius	1.0	28	15	(57)
Mozambique	13.8	85	35	(18)
Niger	6.4	91	47	(21)
Nigeria	99.7	68	36	(4)
Principe and Sao Tome...	(0.1)	—	—	(28)
Rwanda	6.0	93	45	—
Senegal	6.6	81	19	(29)
Seychelles. ...,	(0.1)	—	—	(9)
Sierra Leone	3.7	70	44(10-29)	(39)
Somalia	5.4	76	58	(93)
Sudan	21.9	71	26	(98)
Swaziland	(0.6)	(74)	(10-29)	(44)
Tanzania	22.2	86	58	(71)
Togo	3.0	73	30	(24)
Uganda	14.7	86	(>50)	(90)
Zaire	30.6	72	31	(36)
Zambia.	6.7	73	14	(1)
Zimbabwe	8.4	73	13	(42)

[a]GDP=Gross Domestic Product

NOTES: Figures without parentheses are World Bank data, those in parentheses from FAO. FAO population data is for 1980. Where discrepancies in data were noted, both World Bank and FAO data are included.

SOURCES: World Bank, *World Development Report* (New York, NY: Oxford University Press, 1987); Food and Agriculture Organization of the United Nations (FAO), *Atlas of African Agriculture* (Rome: FAO, 1986).

its meat, 75 percent of its dairy products, and almost all roots and tubers (72). Although significant variations may exist from country to country or village to village, the overall importance of agricuhure to African economies is indisputable.

A Characterlzation of Low-Resource Agriculture in Africa

Although it is difficult to generalize about African agriculture, a close look at the majority of the farming systems used shows that many

share important attributes. Despite the great variation in approaches, most of Africa's agriculture can be categorized as **low-resource agriculture.** Low-resource agriculture is a form of agriculture conducted by a diverse group of poor farmers, herders, and fishers, based primarily on the use of local resources but may make modest use of external inputs, including information and technology. Local resources include the various renewable resources at hand, such as soil, water, and vegetation, etc., as well as local knowledge, labor, agricultural practices and management systems, and local institutions.

External resources refer to those agricultural inputs and technologies (e. g., commercial fertilizer and pesticides, hybrid seeds, tractors, and irrigation systems) and information (e.g., management skills and data) that originate outside the local area and typically depend on continued external support. These external resources are commonly referred to as "modern" inputs because of how they have changed agriculture over the last 50 years, especially in developed countries. The distinction between local and external resources sometimes is not clear. Resources that came from outside of the local area in the past now maybe considered "local" because of adaptation and a long history of use. For example, most of Africa's staple crops (e.g., corn) were introduced from outside the continent but have since evolved unique varieties in various regions.

A Continuum of Resource Use

The definition of low-resource agriculture is a conceptual one that is difficult to quantify, in part because the available aggregate data on African agricultural production do not distinguish the degree of modern input use, only whether or not farmers use them (64).

Resource use in African agriculture is best viewed along a continuum, acknowledging that various kinds of inputs and outputs can change over time or according to what is being raised. African agricultural systems range from small- to large-scale, from using no modern inputs to using many modern inputs, from producing crops and livestock for subsistence to producing them for sale, and from providing low incomes to providing high incomes. However, the vast majority of Africa's farmers, herders, and fishers operate on the lower to middle end of this range and these people are the focus of this report.

The agriculturalists working on the lowest end of the resource use scale are relatively easy to identify: they use no modern inputs, earn little money, and produce goods primarily for their own family's consumption. These people are sometimes referred to as subsistence agriculturalists or low-input farmers (box 3-I). It is possible to estimate roughly how much food this subset of low-resource agriculture produces, which helps establish an idea of the contribution made by these "low-end" low-resource agriculturalists. These estimates are discussed later in this chapter.

Moving up along the resource use continuum, the importance of external inputs increases; farmers may use small amounts of fertilizer and improved crop varieties and herders may have some access to veterinary services. The level of modern input use can vary among farms and herds and even on the same farm between crops and seasons. For example, a low-resource farm in Senegal may grow an improved rice variety using irrigation and low levels of fertilizer as well as an intercrop of local varieties of maize and cowpeas that receives no fertilizer or pesticides.

On the highest end of the resource use continuum are the relatively few high-resource African farms. These include large-scale, privately owned commercial operations (e.g., plantations); large mechanized state-run farms; and large-scale cattle ranches. These agricultural systems rely on greater amounts of inputs, including information and technology and developed support services such as transportation infrastructures, established markets, and input supply. The contribution of these large-scale farms to Africa's food production probably is no more than about 5 percent (47). These operations are not examined in this report.

Box 3-1.—Terms Used in Describing African Agriculture

OTA's use of the term low-resource agriculture is not intended to coin a new phrase or suggest a radically different view of African agriculture. Instead, "low-resource agriculture" is used to emphasize the strong dependence of farmers, herders, and fishers on resources internal to agricultural systems, their poverty, and the existence of combined farming, herding, and fishing practices. Each of these is a defining feature of most African agriculture but not well captured in other terms. While the term low-resource stresses limited resource use, it does not mean *no* use of external inputs (i.e., "no-resource"). Input use varies among low-resource producers and within their operations.

These points are emphasized to varying degrees in related terms used by the development assistance community, including:

- *Low-input agriculture:* As used by FAO, the primary input in these systems is hand labor. No modern inputs (e.g., fertilizer and herbicides) or technologies (e.g., soil conservation techniques) are used ***(67).*** This definition is narrower than that of low-resource agriculture because low-input agriculture includes only those systems at the lowest end of the input continuum where no modern, or external, inputs are available,
- *Smallholding/small farm:* These terms are used frequently to describe African agriculture. They overlap considerably with low-resource agriculture, but differ in two respects: this definition connotes small farm size, a description which is inadequate when talking about pastoralists who use very large areas. Also, the level of external inputs used on small farms is not explicit in the definition. In some cases, smallholders may use high levels of external inputs. For example, smallholders in Kenya's highlands have established a dairy based on crossbred cows, including artificial insemination, input and extension services, and a marketing network. This operation would not be included in OTA's definition of low-resource agriculture because resource-poor farmers use fewer external inputs, regardless of farm size.
- c *Subsistence farm:* Subsistence farms generally gear their production to meeting household needs. By most definitions, no more than 50 percent of the output is sold. While the precise proportion of sales is debatable, the low participation of producers in commercial markets and in cash cropping is the rule. "Subsistence" farms would exist at the lowest end of a resource use continuum. Low-resource agriculture is broader—focusing on food production and rural purchasing power as integrated components of food security.

Some high-input, highly commercialized, but small-scale operations also exist in Africa. These enterprises generally operate in more climatically favorable regions within a select number of countries, tend to be well integrated into national economies, and have good access to national and export markets. Examples include certain smallholder operations heavily geared to export commodities (e.g., coffee and cocoa) that account for a high proportion of Africa's fertilizer and pesticide use. Smallholder commercial dairy operations, such as those in parts of Kenya that rely heavily on input and output markets, might also be included in this category. Although this category provides some insights about how to enhance low-resource agriculture and may benefit from the sorts of technologies outlined in this report, the main focus of discussion here is on farmers and herders at a lower portion of the resource continuum.

Describing Low-Resource Agriculture

Low-resource agricultural systems are typically complex, diversified, and changing, but they generally share certain characteristics:

- they strive to reduce risk, even if this means obtaining less than maximum yields;
- they depend on local knowledge;
- they depend on biological processes and renewable resources;
- they involve low cash costs, but relatively high labor costs and low labor productivity; and
- they are adapted to local cultures and envi-

ronments, although social and ecological systems are showing increasing strains under growing pressures,

The resource-poor agriculturalists who use these systems generally are poor and have limited access to and control over land, water, labor, capital, external sources of information and technology, and external inputs such as commercial fertilizer. Raising food, including livestock, is a major production activity but they may also engage in cash-crop production, fishing or fish-farming, forestry, food processing and marketing, and a host of other income-generating activities.

The range of activities and how they are performed is a response to this group's great vulnerability to factors outside their control. Activities of resource-poor agriculturalists reflect a need to reduce the risks created by fluctuations in climate, the economy, and the political system. This tends to result in lower than optimal yields, but with the benefit of producing household food supplies throughout as much of the year as possible. This strategy has been characterized as a kind of "adaptive diversity" that, while not providing maximal returns under optimal conditions, is able to provide reasonable returns under a wide range of fluctuating and unpredictable environmental conditions (43).

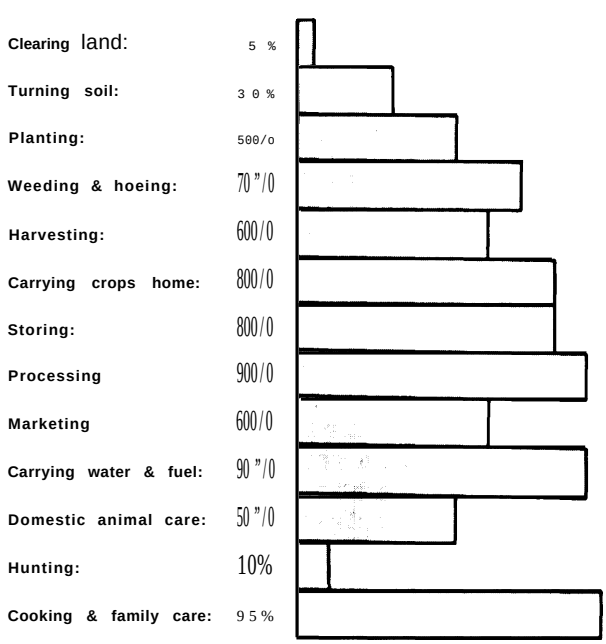
Poverty seriously constrains most farmers from investing in agricultural improvements. It is not unusual for a farmer's total annual capital investment to be under $10 (9,42). Expenditures in the semi-arid tropics of West Africa, where labor commonly is hired, may reach $20 to $60 per hectare (42). Although expenditures other than labor appear to be small, in many cases they represent a high proportion of the capital actually available to a household for expenditures other than food (52).

In low-resource agriculture, the family or household provides the critical source of labor. The division of labor in African agriculture varies across the continent. Men are primarily responsible for land preparation and planting in many areas, whereas women are primarily responsible for weeding and harvesting. In other areas, men are responsible for producing export crops, whereas women work in the production of the export crops as well as in separate fields to produce food for household consumption.

Data from most African countries confirm that women play a major role in agriculture, especially in women-headed households (figure 3-1). Women contribute about two-thirds of all hours spent producing food in traditional agriculture, about 70 percent of the hours devoted to marketing, and at least 80 percent of the hours spent on food processing and storage (31). The elderly and young children of the household also make significant contributions to agricultural production, from scaring birds and harvesting crops to tending small livestock,

The dependence on household labor can lead to seasonal labor shortages as well as periods of underemployment. The need for manual labor is especially high during seasonal activities such as land clearing, tilling, sowing, weeding, and harvesting. These periods represent

Figure 3-1 .-Women's Contributions to African Agriculture



SOURCE: U.N. Economic Commission for Africa, Women in *Africa, 1975.*

peaks in labor demand and available household labor may be inadequate. The ability to meet this peak demand has been further constrained as many young men seeking jobs migrate from rural to urban areas or to distant rural regions for commercial jobs such as those on agricultural estates or in mines. On the other hand, however, seasonal underemployment occurs during times when little agricultural labor is needed, especially in the shorter growing season, semi-arid regions (50).

Low-resource agriculture thus can be seen as a livelihood meeting multiple needs, and it involves balancing scarce endowments of land, labor, and capital. For the farmer or herder, this involves a complex decisionmaking process that regularly requires difficult trade-offs. This complexity also creates challenges for researchers trying to decipher the process. Analyses that focus narrowly on only one particular activity in low-resource systems can lead to misguided or inappropriate conclusions about how to improve that activity since the assistance may be inconsistent with the overall household production system. For example, new technologies that require increased labor, particularly during peak labor periods, may not be feasible for a farming household to adopt if it means drawing someone's time away from other important activities.

Although low-resource agriculture was once perceived as inefficient and somewhat haphazard, recent investigations have given rise to a far greater appreciation of the efficiency and logic of various systems and practices—given families' available resources and multiple objectives. Further discussion of the features of low-resource agriculture and their implications for development assistance is provided in chapter 4. Boxes 3-2 and 3-3 illustrate two particular low-resource systems.

AN AGROECOLOGICAL VIEW OF LOW-RESOURCE FOOD PRODUCTION

Socio-economic factors are extremely important in defining the nature of low-resource agriculture. It is also essential, however, to evaluate how agroecological factors help define production in low-resource agricultural systems. The discussion that follows is organized around four broad agroecological zones (box 3-4). This organization provides an overview of African agriculture and is a simple way to address various management and development assistance issues. Reality, however, is rarely simple. Each zone on the map includes a wide range of agroecological conditions that reflect heterogeneity at the microlevel. Each zone is likely to produce some of each particular crop and kind of livestock and multiple crop and livestock varieties tend to be raised together. Home gardens are important in all zones, for example. Defining only the major food crop also masks the importance of the cash crops grown, as well as the importance of the many non-farm activities pursued by low-resource agriculturalists. Thus, the following regional sketches and the summaries inbox 3-4 are intended simply to illustrate the relative importance of major crops and livestock in each zone.

Arid and Semi-Arid Tropics

Millet is the predominant crop in Africa's drier areas, where it is commonly the only cereal that can be grown under rainfed conditions. Sorghum replaces millet as the principal crop in wetter areas or on more moisture-retaining soils. Maize, which is less drought tolerant than either of the other two cereals, is produced to a small extent in this zone. Whether grown separately or intercropped, millet and sorghum are typically grown under low-resource conditions using local varieties and little or no fertilizer or pesticides (1,42,48,75) (app. D). Rice is an important crop but its production is restricted to river basins. Although some improved varieties are used, less than 5

Box 3-2.—Profile: The Life of a Farmer*

Malawi is a landlocked country in southern Africa, bordered by Tanzania, Zambia, and Mozambique. At least 80 percent of the people in Malawi are rural and make their livings farming. In the center of the country is a broad plateau called the Lilongwe Plain—an area of good soils and adequate rainfall that is the granary for the country. It is here that Sindima lives on a farm of about 2 1/2 hectares that includes land she inherited from her mother and land that belongs to her husband.

Sindima is in her late thirties and has five living children; two other children have died, and it's likely that she will have two or three more children in time. She is head of her household—which is not unusual in Malawi, where at least one-third of all rural households are headed by women. Sindima's husband moved to Lilongwe, the capital, to find work. It takes 2 days for him to walk home, so she sees him infrequently. This means the traditional division of labor on their farm has shifted-in their grandparents' time, the men did all the heavy work, like clearing new land, plowing, or building fences, and the women did all the planting, weeding, harvesting, and processing. In her family, decisionmaking was shared. Now, however, Sindima makes almost all the management decisions, and she and her children do all the work. Since most of the land is under continuous cultivation, there is little opportunity to clear new lands, which is one of the reasons her husband felt compelled to leave for the city.

By local standards, Sindima is affluent. Because she and her husband belong to a local farmers club, she has access to the extension agent for information. A development assistance project supplies credit in the form of some fertilizer and improved seeds, which she will pay back when she sells the crops after the harvest. With this help, she plants a more complicated mix of crops than many of her neighbors—hybrid and local maize, groundnuts, beans, a variety of local vegetables, and a little tobacco. She uses the fertilizer and improved maize on about one-half hectare, but she continues to plant local maize even though it is less productive because it tastes better and is less susceptible to insect damage in storage.

Sindima is quite knowledgeable about managing her fields, particularly the garden crops she grows near the house. Because she has a relatively good size farm, Sindima is able to grow some maize and tobacco as monocrops, which simplifies the labor and management required. Like most of her neighbors, however, most of her land is intercropped and she has a sophisticated understanding of crop rotation, planting times, weeding requirements, and allocation of labor. Sindima knows it is important not to overwork the land. But it's more difficult now than ever to let a field lie fallow to regain fertility because of the pressure she feels to produce the most she can from her small farm.

In the past, Sindima took some extension classes on nutrition and sewing, but only recently have they let women take the farming courses. She hopes to take a course about using the improved maize varieties soon, because she has been learning by trial and error so far. Of course, finding time for classes is hard when she almost always has something to do in the fields or her household. Just grinding maize enough for her own family takes hours; so does finding enough firewood. She keeps some chickens and goats, too, which have always been the woman's responsibility. Her children help with many tasks—the two older girls walk to the community well twice each day to get water, and everyone helps with harvest—but she wants them to stay in school. With the money she makes at market (she not only sells crops, but also a little tobacco and home-brewed beer) and the money her husband sends, she can pay their school fees and sees education as a high priority.

Sindima illustrates what can be accomplished on a small farm with few resources—but she has an advantage over many other women who farm alone. After all, she has a husband sending money, two parcels of land, and access to the agricultural extension system. Her cousin Nanthalo, on the other hand, is younger, divorced, with three small children. To make ends meet, she hires out to help others with planting and weeding, but this interferes with the time she has to devote to her own fields. (Since this is a matrilineal society, she kept her land when her husband left; in many other countries, she would be worse off because all land belongs to the men.) She does not have the money to keep her children in school, and her child care responsibilities keep her from taking an extension classes. With only one small parcel of land, her farm is too small to be eligible for credit packages or other help from extension. She gets by as she can, and depends on help from relatives like Sindima. While Sindima illustrates the potential of low-resource farming styles in Malawi, Nanthalo may well be more typical.

● Sindima is fictional but this profile is a composite drawn from the lives of real people.

SOURCES: Anita Spring, Associate Dean, College of Liberal Arts and Sciences, University of Florida, Gainesville, FL, persona] communication, *1987,* and "Profiles of Men and Women Smallholder Farmers in the Lilongwe Rural Development Project, Malawi, " report to Office of Women in Development, U.S. Agency for International Development, Washington, DC, March **1984.**

Box 3-3.—Profile: The Life of a Nomadic Herder*

The Sahel region of West Africa is vast and dry, a seemingly inhospitable land. Yet for 6,000 years, nomadic herders have made productive use of what is, to many, a marginal environment, They have learned to use the ecosystem to their advantage, moving when they must seek water and forage to satisfy their livestock.

Mossa is a herder, like his father and his father's father, He is in his forties, the youngest of nine children, and has lived his life in an area north of Timbuktu, Mali. He and his wife have three sons and four daughters still alive; four other children have died. Mossa's life is typical of that found in this large expanse of arid and semiarid land, although from a broader perspective he illustrates only the lifestyle of the 6 percent of Africa's population that is nomadic.

Animals are the core of life for Mossa and his family. Cattle, sheep, and goats provide milk, butter, cheese and, for special occasions, meat. The heavy tents Mossa and his family live in—strong enough to withstand high winds, sand storms, and the driving rain of the wet season—are made of hides, as are their sandals and many household goods. When the family needs grain or other goods, Mossa sells or trades what he must from the herd. His herd size is respectable by local standards; he has some cows, calves, and heifers, plus a number of goats and some sheep, Mossa, his father, and others before them have carefully applied their knowledge and management skills to these animals and their breeding. And while Western veterinary medicine is not generally available, he has a variety of traditional, and often effective, methods for treating his animals.

The herd represents more than a source of income to Mossa and his family. It is a measure of their wealth, status, and security. This is not merely a matter of pride: livestock are their "bank account," their way of saving resources for bad times in a land that has unpredictable but frequent droughts.

Mossa's nomadic community consists of about 10 related families who move together with their livestock following good pasture and water. During the dry season, they break camp before dawn and travel before the heat of noon. They camp near a particular well as long as the pasture holds out—usually a matter of a few weeks. During the wet season, they move more frequently to take advantage of the better forage. They must always camp within about 10 km of water because their small livestock must be watered every day.

Life is changing rapidly for Mossa now. He has far more contact with urban people than his father did, and this has changed his and his family's expectations. They buy more household goods and eat some different foods. Young men from the community are far more likely to leave now and go to the city in search of work, which changes the family structure for those that remain. Mossa's ability to make a living from the land is changing too. Some productive lands he once grazed have deteriorated, like the area around the government-dug deep well. It was a good idea gone awry: water is always needed, but too many animals concentrated around one water source stripped the land of its vegetation, starting in motion a chain of erosion and degradation. In other places, crop farmers have taken over land where he and his family once grazed their livestock. In particular, one area he traditionally used during dry periods has become part of a large landholding owned by an absentee civil servant, and he can no longer go there. His risk has increased: during the next severe drought, Mossa will probably lose a large part of the herd. Mossa still has yet to recover from the last drought when, like most other herders, he lost half his animals.

During this recent drought, for the first time Mossa was unable to feed his family. International assistance organizations provided food aid to Mossa's community, but little else. Indeed, Mossa sees fewer donor-supported livestock projects than he did a decade ago, and he wonders whether his own government or any of the many other groups that attempt to help really know how to help him improve his life,

● Mossa is fictional but this profile is a composite drawn from the lives of real people.

SOURCES: American Friends Service Committee (AFSC), ***Tin Aicha Nomad Village*** (Philadelphia, PA: AFSC, 1982); Michael M. Horowitz, ***The Sociology of Pastoralism and African Livestock Projects,*** AID Program Evolution Discussion Paper No. 6. (Washington, DC: Bureau for Program and Policy Coordination, AID, May 1979); George S. Scharffenberger, Consultant, Washington, DC, personal communication, 1987.

percent of the rice production in Africa consists of High Yielding Varieties, unlike most other parts of the world where these are used extensively (13).

Food legumes, especially cowpeas, are often intercropped with cereals under low-resource conditions. Root and tuber crops are less important in the arid and semi-arid zone than in others, but they provide a small percentage of the dietary energy supply (72).

About 60 percent of tropical Africa's ruminant livestock and virtually all of the continent's estimated 11 million camel live in the arid and semi-arid zone (30,60). The region is characterized by a low livestock/land ratio, but a high livestock/human ratio. Pastoralist systems of various kinds prevail. For example, nomadic systems, which occupy the drier regions of the Sahel that are unsuitable for crop production (i.e., rainfall less than 300 mm/yr), use nutrient-rich natural vegetation produced during the short rainy season. These people then move south during the dry season. Transhumant pastoralists—those who are mobile around a fixed base–are most common in the semi-arid zone receiving 300 to 600 mm/yr of rainfall. Sedentary agropastoralists—those who remain in one place—have become increasingly common in more favorable areas within this zone. An estimated 40 percent of Sahelian cattle and even larger percentages of small ruminants are being raised under this system (82).

Virtually all of the rangeland livestock production in the arid and semi-arid zone can be considered low-resource agriculture. In Sudan, for example, an estimated 90 percent of livestock is produced with virtually no outside inputs (app. D, 75). The exceptions are ranching activities that are important in a few southern African countries, such as Botswana and Zimbabwe. Overall, however, ranching activities in Sub-Saharan Africa probably account for only about 6 percent of Africa's livestock production (7].

Subhumid Tropical Uplands

Sorghum and maize are the predominant cereals in Africa's subhumid tropical uplands. In this zone, sorghum is the preferred cereal for drier conditions and whereas maize is more common in wetter areas. Maize commonly receives some modern inputs. Compared to millet and sorghum, it is not clear how much of the maize production should actually be considered "low-resource." For example, in the leading maize-producing countries—Zimbabwe and Kenya—most land is planted with hybrids (15). Yet most countries across all agro-ecological zones report low national productivity averages (e.g., Ivory Coast: **660** kg/ha, Zaire: 780 kg/ha, Angola: 510 kg/ha-compared to 1,940 kg/ha average in Zimbabwe) (72), an indication that most maize is produced under low-resource conditions.

Roots, tubers, and plantains are also prevalent in subhumid areas, although less so here than in the humid lowlands. As in the arid and semi-arid zone, food legumes and rice are also produced.

N'Dama and Zebu cattle are the most economically important livestock in the subhumid zone, followed by goats and sheep (30). Grazing densities are low, on par with the arid zone and less than one-quarter of that in the highland regions. Low productivity is the result of nutritionally deficient forage (i.e., inadequate protein and minerals), despite the generally favorable quantity of forage growth (28). Also trypanosomiasis prohibits livestock production in about two-thirds of the subhumid zone (63).

Livestock and crop production are not well integrated in mixed farming systems, although close links often exist between pastoralists and farmers, especially in West Africa. Examples of links include exchanges of food crops for livestock products, exchanges of post-harvest fodder for organic fertilizer (manure), and reciprocal labor arrangements (40). Increasingly, however, these complementary relationships seem to be overshadowed by competition for land and resources (40).

Humid Lowlands

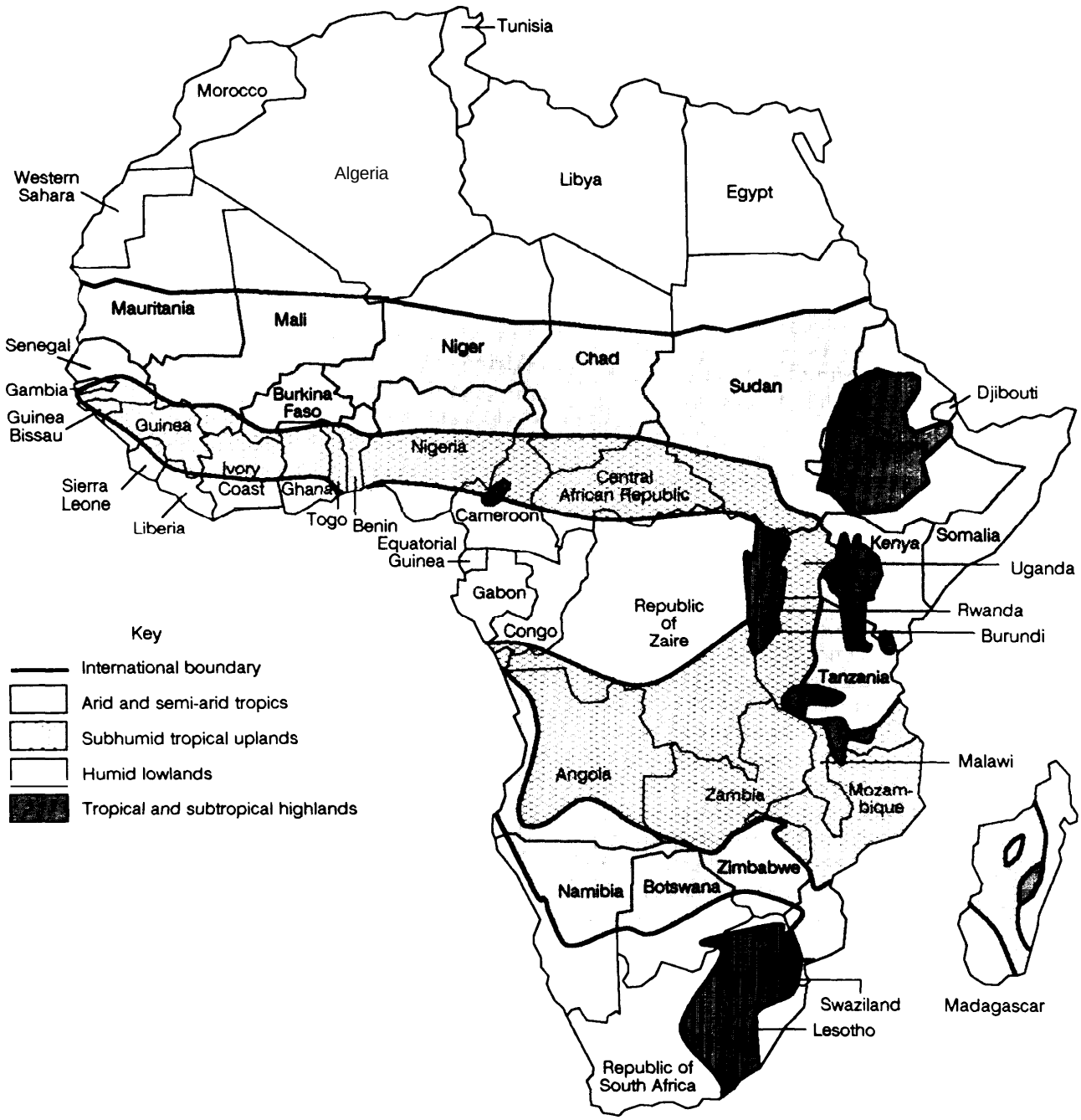
Roots, tubers (e.g., cassava, yams, sweet potatoes, and cocoyams), and plantains are the predominant crops and major sources of calories

Box 3-4.—African Agroecological Zones and Primary Food Commodities

Agroecological zone	Length of growing period[a] (days)	Annual rainfall	Primary food commodities
Arid and Semi-Arid Tropics	1-74 (arid) 75-180 (semi-arid)	100-1,000 mm	Little cultivation in arid areas. Millet and sorghum predominant, with millet grown in drier areas. Maize in wetter areas and rice in river basins. Food legumes (e.g., cowpeas and groundnuts) important and some roots and tubers grown in wetter areas. Approximately 60% of Africa's ruminant livestock (goats, sheep, cattle, and camels) raised here by both nomadic and settled pastoralists.
Subhumid Tropical Uplands	180-270	900-1,500 mm Bimodal rainfall in East Africa	Sorghum and maize are the most important cereals, with sorghum preferred in drier areas. Roots, tubers, and plantains are important. Food legumes and rice also produced. Two-thirds of the zone are affected by trypanosomiasis (spread by the tsetse fly) which inhibits livestock production. N'Dama and Zebu cattle are the economically most important livestock followed by goats and sheep,
Humid Lowlands	***270 +***	***1,500+*** mm Bimodal rainfall	Roots, tubers, and plantains predominate (e.g., cassava, yams, etc.) Some maize, rice, and sorghum. Trypanosomiasis exists throughout the zone precluding almost all but the small trypano-tolerant N'Dama cattle and tolerant goats and sheep. Some poultry and swine production.
Tropical and Subtropical Highlands	Variable	Variable	Mixed farming (livestock and crops raised on same farm) prevails. Predominant cereals are maize and sorghum, Roots and tubers (especially sweet potatoes) are important in specific countries. Plantains and food legumes are also grown. The absence of trypanosomiasis and availability of good fodder allow a stocking density four times the average.

[a]Length of growing period is the period when both moisture and temperature permit crop growth.

SOURCES: U.S. Agency for International Development, Bureau for Africa, ***Plan for Supporting Natural Resources Management in Sub-Saharan Africa,*** (Washington, DC: USAID, February 1986), Food and Agriculture Organization of the United Nations, ***African Agriculture: The Next 25 Years Atlas of African Africulture*** (Rome, FAO: 1986]. International Livestock Center for Africa, ***ILCA Annual Report 1983*** (Addis Ababa, Ethiopia: ILCA, 1984],



SOURCES: Adapted from U.S. Agency for International Development, *Plan for Supporting Natural Resources Management in Sub-Saharan Africa*, (Washington, D.C.: USAID, February 1987). Zonation for Madagascar from U.N. Food and Agriculture Organization (FAO), *African Agriculture: The Next 25 Years – Atlas of African Agriculture* (Rome: FAO, 1986); International Livestock Center for Africa (ILCA), *ILCA Annual Report 1983* (Addis Ababa, Ethiopia: ILCA, 1983).

throughout the humid lowlands (72). These are grown almost completely under low-resource conditions (27,74,75) (app. D). While most of these crops can be grown under widely ranging rainfall and soil conditions and therefore are produced in all agroecological zones, cocoyams are restricted to the humid lowlands (25). Maize, rice, and sorghum are grown in various parts of this zone, as are a wide range of food legumes and vegetables.

Although the humid zone comprises almost 20 percent of Sub-Saharan Africa, it accounts for only about 7 percent of the ruminant livestock production. Virtually the entire humid zone is infested with tsetse fly, precluding almost all but the small trypano-tolerant N'Dama breeds of cattle. Goats and sheep, which are more tolerant of trypanosomiasis, assume greater importance in this zone, although other diseases (e.g., Peste de Petit Ruminant) and parasites can restrict their production. However, women manage a few small ruminants in most areas in conjunction with their home gardens.

Poultry and swine production are of particular importance in the humid zone, particularly near population centers. Swine production, restricted in many areas because of disease and religious taboos, is most common in humid coastal regions. Rapidly increasing demand for poultry, and to a lesser extent swine, has promoted intensification in traditional production systems. A significant share of these production increases are possible because of imported large-scale commercial production technology being developed near urban centers (82).

Tropical and Subtropical Highlands

Even though the highlands contain no more than 5 percent of Africa's land area, generally favorable agroclimatic factors enable it to support nearly 20 percent of the region's rural population. The zone produces a wide range of crops. Cereals, primarily maize and sorghum, predominate in most countries. However, root and tuber crops, especially sweet potatoes, are more important in such countries as Rwanda and Burundi (72). Plantains and food legumes also contribute to the diet.

Livestock production, especially cattle, is an important activity, with almost 20 percent of Africa's ruminant livestock production occurring in the highlands (22). Generally fertile soils, moderate temperatures, and ample rainfall result in relatively high fodder production. These factors, combined with the absence of trypanosomiasis and the use of high-yield imported breeds and cross-breeds, allow a stocking density almost four times the average for Africa.

Most farming in the highlands, consists of mixed systems where crops and livestock are raised in the same management units (22). This is the only zone where such integration is well developed. High human population densities, relatively well-established distribution systems, and numerous markets have led to progressively greater use of purchased inputs. In the most favorable highland regions, many small-scale farmers have established highly commercialized operations, using predominantly high-yielding crop varieties and modern inputs such as artificial insemination services for livestock.

CONTRIBUTIONS OF LOW-RESOURCE AGRICULTURE TO AFRICAN FOOD SECURITY

Low-resource agriculture makes a crucial contribution to African food security[1] because it is significant to household food production and income generation. Low-resource agriculture is the source of most of Africa's food, a primary income and employment source for the majority of Africans and African governments, and a strategy used by many of Africa's most

*Food security can be defined as access by all people at all times to enough food for an active, health life; food security depends on both the availability of food and the ability to acquire it (79).

vulnerable people to buffer themselves against food shortfalls and famine.

Producing Most of Africa's Food

The majority of food production across Africa, is by low-resource agriculture. Low-resource agriculture produces the majority of grain, except wheat and perhaps maize. Almost all root, tuber, and plantain crops, and the majority of food legumes are produced on low-resource farms (table 3-2). In addition, a great variety of secondary crops such as fruits and vegetables are grown under low-resource conditions to supplement these staples (app. D, 75).

An estimated 75 percent of all livestock in Sub-Saharan Africa is raised on farms where crop production is the principle source of subsistence, and livestock are an important source of cash income. Most of these livestock receive little supplementary feed or health care (7) and their production can be considered "low-resource." Approximately 20 percent of live-

Table 3-2.—Low-Resource Agriculture and African Staple Food Production[a]

Crop/livestock/fish	External input use[b]	Minimum estimate of low-resource production
Millet	Virtually no use of fertilizers and very little use of improved seed.	720/o
Sorghum	Basically the same situation as millet, but hybrids and commercial inputs are becoming more important in some areas.	61 %
Maize	At least 75 percent produced without hybrid seeds and with less than recommended fertilizer levels; but probably as much as two-thirds produced with non-hybrid improved seed and moderate levels of fertilizer.	37%
Rice	At least 75 percent produced using less than recommended levels of fertilizer and receiving inadequate irrigation (and no more than 5 percent using High-Yielding Varieties).	760/o
Food legumes (e.g., cowpeas, pigeon peas, beans, and groundnuts)	Most crops of this diverse group receive virtually no commercial inputs, but some production is under higher-resource conditions (e.g., up to 50 percent of groundnut production).	55°/0 groundnuts 49°/0 beans
Roots, tubers, and plaintain (e.g., cassava, yam, cocoyam, and sweet potato)	Virtually no use of fertilizers or improved seed. Some high-resource banana production for exports.	93% cassava 100% yams 100% cocoyam
Cattle	Six percent produced on ranches, generally considered high-resource; 20 percent produced by pastoralists, virtually all under low-resource conditions except for occasional veterinary care; 74 percent produced in mixed farms, a minority of this under higher-resource conditions, such as dairy farming in some highland areas.	
Small ruminants and other livestock (e.g., sheep, goats, poultry, and swine)	Almost all sheep, goats, and camels raised under low-resource conditions; most swine and poultry produced under low-resource conditions, but increasingly more produced under higher-resource conditions, especially near some urban areas.	
Fish	As much as 85 to 95 percent caught in small-scale artisanal fisheries mostly under low-resource conditions, though increasingly fishers are using outboard motors; the remainder is harvested by large-scale offshore operations mainly by foreign-owned vessels.	

aAggregate agricultural data for Africa usually do not detail levels of external input use but only whether Or not such inputs are used. Table 3-2 shows the importance of low-resource production in two ways. First, it describes the type of input use for the Production of specific commodities and second, it sets a minimum boundary on the volume of low-resource production of specific crops, based on estimates on "low-input agriculture" production in eight African countries.

bColumn 2 provides descriptions **of the types and levels of external inputs used for specific products. These descriptions help to locate where the majority of production takes place along the range of modern in Put use. The descriptions were compiled from a set of technology papers written for OTA (app. A) and additional outside publications.**

cColumn *3 represents an* **effort** to **establish quantitative estimates of the minimum contributions of low-resource** agriculture. The **data show production under conditions of no modern input use *for* eight sample countries. These eight countries account for at least 50 percent *of* African production of maize, sorghum, millet, cocoyam; and no less than 30 percent of cassava, groundnut, and rice production. The data were compiled by the Economic Research Service of the U.S. Department of Agriculture for OTA. (See app. E)**

SOURCE: Office of Technology Assessment, 1988,

stock production occurs in pastoral systems, where animals are the major source of income and food (milk is often more important than meat) (63). Pastoralist systems, by their nature, are low-resource enterprises, although some use of veterinary services is becoming more common. Just over 5 percent of Africa's livestock is raised on higher resource ranches (7).

Fish are a principal source of animal protein in many parts of Sub-Saharan Africa (17). An estimated 85 to 95 percent of African fish harvest is from traditional artesanal fisheries—small-scale operations that do not use expensive equipment or inputs (44,53) and fall within a definition of low-resource agriculture.

The Primary Employer and Major Source of income

An estimated three-quarters of Africa's labor force are involved in agriculture, and a large majority of these workers are engaged in low-resource farming and herding. For them, farming and herding systems represent their primary source of income as well as food. The sale of food and other agricultural products accounts for between 60 and 80 percent of the income of most rural producers in Africa (21, 24). Other non-farm activities also represent important sources of income but are most often pursued in conjunction with, rather than in place of, on-farm activities.

Low-resource agriculture is of particular importance for African women, who constitute the major food producers in most African countries and account for about one-half the agricultural labor force (3). Women also earn a significant portion of household agricultural income because of their predominant role in marketing activities—selling agricultural products (e.g., peanuts, vegetables, or grain) and generating income from processing activities (e.g., cheese, beer, or soap-making). The role of women as farm managers is also growing in importance. Although women typically engage in some autonomous activities within male-headed farming households (e.g., managing separate fields), the number of female-headed households is increasing as growing numbers of men seek work away from the farm.

Low-resource agriculture contributes to national as well as household income. Agriculture's share of the gross domestic product of African nations averaged approximately 41 percent between 1982 and 1984 (81). In addition, agricultural production contributed significantly to the export earnings of many countries. Agricultural exports in 18 countries, provided at least 50 percent of the value of total exports in 1983. In another 12 countries, they provided at least 20 percent (72).

The exact contribution of low-resource agriculture to exports is difficult to estimate. Data show that low-resource agriculturalists produce more food crops than cash or export crops such

Photo credit: U.S. Agency for International Development

Low-resource agriculture provides income for a large proportion of Africans. Women play a large and growing role in the continent's farming systems.

as coffee, cocoa, cotton, and rubber (app. D, 75). The latter crops tend to receive the highest input levels, and in this sense are less likely to be considered low-resource. However, there are important links between the production of these exports and food crops.

A sizable proportion of export crops, perhaps even a majority, are produced by small farmers who are also producing food crops under low-resource conditions. USDA data show, for example, that in Kenya 64 percent of coffee exports, 40 percent of tea exports, and nearly 100 percent of cotton exports are produced by smallholders, Even in Malawi, with its large tea, sugar, and tobacco estates, smallholders accounted for an estimated 64 percent of the value of agricultural exports in 1979/80 (64). If local markets cannot provide a dependable food supply for these farmers, they will devote more of their resources to growing food, thereby constraining their export crop production and consequently reducing national exports (64). The result can be a decline in foreign exchange earnings and fewer resources for governments to devote to economic development, including the agricultural sector. In turn, the use of modern inputs and other investments in agricultural improvements, made affordable by growing cash or export crops, can have a direct or residual benefit on food crop production. For example, fertilizer remaining in the soil after its application for a cotton crop benefits the subsequent, unfertilized, rotation of millet (64).

A Buffer Against Famine

Resource-poor agriculturalists commonly face periods of inadequate food availability. Seasonal shortfalls can occur annually when food from past harvests is exhausted but before new crops can be harvested. For herders, inadequate access to suitable dry-season fodder generally results in shortfalls in milk production, the major source of nutrition for pastoralists. These seasonal shortages are sometimes called the “hungry period. ” Famine, on the other hand, is a more extreme incidence of food shortfall with no set period.

The practices of resource-poor farmers and herders have evolved as responses to reduce the impacts of these periods of acute hunger, which are too common events in many parts of Africa. These include diversification of crop and animal production, root crop production, collecting wild foods in the bush, as well as many social mechanisms. Other responses—such as seeking non-farm employment or migration—are not examined here.

One characteristic of low-resource production systems that reflects a concerted effort to buffer against famine is the raising of different crop and livestock species and varieties (56). This diversification minimizes the risk of total crop failure. In addition, it reduces the incidence of food shortages by ensuring some production during year-to-year fluctuations in climatic conditions, increasing expected returns by fitting various types of crops to particular micro-environments, and by spreading food production throughout the year. Herders achieve similar goals by raising several livestock species. Multi-species herds make better use of available pasture and offer a more continuous supply of food because of differences in periodicity of growth, milk production, and reproductive cycles (16,20).

Another buffer against famine is the common practice of growing roots and tubers. Because most roots and tubers in Africa are grown under low-resource conditions they are sometimes referred to as “poor peoples crops. ” Cassava, for example, is a highly productive staple that grows in low-fertility soils where few other crops can. It requires little labor to produce, and can be stored—simply left unharvested in the ground—until the hungry period between harvests. The fact that *cassava* is a staple crop among the poor has been partially responsible for its neglect among agricultural researchers (51).

Resource-poor farmers may also make extended use of undomesticated plants and animals during hungry periods. Farmers and herders often have a wealth of information on various wild resources, and may directly or indirectly promote their growth in surrounding

Photo credit: Consortium for International Crop Protection

Cassava is a "poor people's crop" because it grows where little else can, requires little labor to produce, and can be stored in the ground until seasonal food shortages strike.

areas. Although collecting wild foods and products can be important to household nutrition and income throughout the year, the collection of wild foods increases during hungry periods and certain wild foods are used only during these times (8,18,44).

Resource-poor farmers also have established a variety of social mechanisms to help seriously affected households survive periods of food shortfalls. These social mechanisms may be based on relationships such as kinship, affinity, or patron-client relations. For example, reciprocal food sharing is sometimes used to minimize starvation in a community while food supplies last (51). Livestock may be loaned to a household that has suffered serious losses of their herd. The loan arrangement economically benefits the lender by increasing the labor available to tend the herds, while the borrower receives milk, manure, and perhaps, rights to the progeny (62).

Most low-resource farmers and herders are relatively isolated from national markets and this is a major reason why these individual efforts to provide buffers against famine are so important for African food security. This was vividly illustrated during the mid-1980s drought: serious food shortages occurred in countries that actually had excess food, but governments were unable to transport and market it in the drought-affected areas. Also, small-scale farmers without other sources of income and pastoralists who depend on selling animals for cash must use their crops and animals themselves during a famine. As a result, they, along with landless agricultural workers, often lack the purchasing power to buy food even if it is available during a famine (79).

Therefore, an important aspect of dealing with food security issues in Africa is not simply the availability of food within the country, but also whether the vulnerable populations have access to it. For much of Africa this means promoting improvements among low-resource agriculturalists and, at the same time, not disrupting those mechanisms used to buffer against famine.

LOSING GROUND: CONCERNS FOR AFRICAN AGRICULTURE

African agriculture has continuously, and for the most part effectively, adapted to meet changing conditions. But never before has it had to respond to the level of pressures it currently faces. Paramount is the pressure created by rapidly growing populations and the consequent demands on the land. The resulting negative changes in agricultural land use are evident in most regions–reduced fallow, falling yields, and natural resource degradation. Per capita food production and income, as well as nutritional levels, are dropping. Although the severity of the problems varies greatly among countries, the overall threat is serious and likely to get worse before it gets better.

Africa's Population Challenge for Agriculture

The African continent has the most rapidly growing population in the world. The estimated rate of population growth is 3 percent per year, a rate that increases Africa's population by 1 million people every 3 weeks. Although the

United Nations and the World Bank project that population growth will drop to 1 percent by the year 2045, at current rates of growth Africa will have three times its current population to feed in just 40 years (83).

Population density in Africa, however, is relatively low, with an average of about 60 people per 100 hectares of cultivable land. This is about one-third the average for the developing world (79). These averages, however, hide the severe consequences of high population growth in those areas where population concentrations are already great, and in areas lacking the resources to support dense populations. For example, resource scarcity and intense population concentration are already acute in countries such as Rwanda and Burundi where the population densities are the greatest in Africa. Farm size in some parts of Kenya, where population is growing at an estimated 4 percent per year, now averages no more than 1 hectare.

In the past, the widely used practice of shifting cultivation was an effective traditional agricultural system in most parts of Africa. This is a form of production where farmers use simple tools to clear the land, then burn the debris so the ash serves as fertilizer. They leave or prune useful shrubs and trees. Then they plant seeds or other material, cultivate the site for a few years, and move to another area when yields fall and weeds begin to suppress crops. The previously cultivated site regenerates naturally during a fallow period until the cycle begins again (54).

Although scientists formerly viewed shifting cultivation as a primitive and inefficient form of farming, they increasingly recognize it as a culturally integrated, economically rational, and ecologically viable practice. This holds true, however, only as long as population densities are low enough to ensure adequate fallow periods to regenerate soil fertility and a new vegetative cover (61).

In many parts of Africa today fallow periods are too short. For example; fallow periods have been reduced from 12 to 2 years in Burkina Faso and from 20 to 5 years in Angola [4). When the average fallow period dropped from 5.3 to 1.4 years in Nigeria, cassava yields fell significantly (35).

This raises a fundamental problem for African farmers: can local innovations and adaptations in their current farming practices ensure their food security while facing the pressures of increasing population densities? Quantitative study of this issue is largely lacking. However, one study in Nigeria raises serious concerns by concluding that:

> (Farmer) adaptations were obviously able to slow the process of diminishing yields (resulting from reduced fallows], but they are insufficient to stop the process. . . without additional income from off-farm employment, the households in high population density areas could not provide their daily food requirements (35, p. *116).*

Although this conclusion relates specifically to a Nigerian case study, the general conclusions regarding the declining sustainability of many low-resource food production systems can confidently be extended to numerous other regions. One study, for example, concludes that 22 countries in Africa (including North Africa) were unable to feed their populations from their own land resources with existing practices as early as 1975. The number of countries unable to meet their needs with their own land resources is projected to reach 29 by the year 2000 (representing 60 percent of the region's total population) in the absence of significant increases in inputs and conservation measures (68).

Signs of Decline in African Agriculture

A number of additional signs indicate serious problems ahead for Africa's low-resource farmers and herders. For instance, declining per capita food production and income are making it more difficult for Africans to grow or acquire enough food to meet adequate nutritional standards. Perhaps the most insidious aspect of the problem is the inter-locking and self-reinforcing nature of these negative trends—namely poverty, malnutrition, poor

agricultural performance, and environmental degradation.

Declining Per Capita Food Production

Africa's food problems are not caused by decreasing food production—the production of many food crops has actually increased—but rather by increasing population growth (72). Although total food production increased 1.8 percent annually for Africa as a whole between 1980 and 1984, population growth outpaced these increases. Therefore, per capita food production fell 1.3 percent annually between 1971 and 1984. Some exceptions exist, however, where specific countries have had significantly lower per capita declines and, in a few cases, increases (72).

Lags between food production and demand have caused a need for increased food imports. The changing balance between exports and imports of basic foodstuffs in Africa (including wheat, rice, coarse grains, and dairy products) reflects the negative effects of Africa's declining food production and increasing demand. From the late 1960s to the late 1970s, Africa changed from a net exporter of staple foods to a net importer, with food imports rising by 140 percent and exports declining by 52 percent (59). The value of exports in 22 countries in 1986 was not sufficient to pay for imports (72). In this way, low-resource agriculture's failure to keep pace with population growth also has contributed to the problems of trade deficits and scarcity of foreign exchange.

Declining Per Capita Income

Although low-resource agriculture has been a primary source of income in Africa, the income provided has not been adequate to ensure food security. Per capita income in Africa's low- and middle-income countries decreased by an average of 0.4 percent per year during the 1970s. For comparison, low-income countries in Asia saw increases in per capita income of 1.1 percent per year, and middle income countries saw a 5.7 percent increase during the same period (36).

Not only is the overall trend in Africa toward decreasing incomes, it is also one of increasing maldistribution of incomes and income-producing resources, such as land and livestock. For example, in Nigeria the share of land owned by the poorest farmers has decreased while the share owned by the richest farmers has increased. In Botswana and Somalia, the higher economic groups among the pastoralists increasingly control most of the livestock (21).

Declines and fluctuations in income have particularly severe effects on Africans because a greater percentage of their income is spent on food than in other parts of the world. For instance, Tanzanians spent about 60 percent of their total income on food in 1975; in Niger, people spent almost 65 percent. This can be compared to Hondurans who spent about 45 percent; Japanese, approximately 20 percent; and Americans and Canadians, who spent 10-15 percent of their incomes on food (41). This trend particularly affects the urban and rural poor, who spend a greater proportion of their income on food than the wealthy (21).

Increasing Malnutrition

Under normal circumstances, low-resource agriculture provides most countries in Sub-Saharan Africa with adequate dietary energy supplies (DES, a measure in kilocalories/per capita/per day). Dietary energy supplies in 31 African countries are near or above the average recommended requirement of 2,100 kcal per day. Ten countries, however, have DES levels that do not reach the recommended level and four of these are near or below the critical requirement of 1,800 kcal/day (72). Even within countries with acceptable DES levels, some people eat less than an adequate level.

These dietary trends provide further evidence that low-resource agriculture's ability to meet Africa's food needs is declining. Sub-Saharan Africa is the only region in the world where the dietary energy supply has declined over the past decade (72). In 1980, an estimated 150 million people in 37 African countries did not receive enough calories to support an active work-

ing life and, of these, 90 million did not receive enough to prevent serious health risks (79). As many as 90 percent of the malnourished people in Sub-Saharan Africa are poor agriculturalists (39). Their malnutrition is chronic but periods of acute food shortage occur during the planting season, just when people most need their strength to continue farming (76).

Deteriorating Natural Resource Base

Resource degradation problems vary by region, but almost all of Africa is affected (table 3-3). Approximately 35 percent of non-' 'desertified" land in Africa currently is at risk of future desertification (73). At risk are such important resources as soil quality and vegetative cover, including trees.

Soil erosion, salinization, and drainage problems are causing physical and chemical degradation of African soils, and reducing land productivity, Water erosion is the major cause of soil loss in Africa. Wind erosion is also a problem, particularly in more arid regions. Compaction or crusting of the soil caused by shortened fallow periods, reduction of soil organic matter, and improper mechanical tillage are sources of serious degradation of the soil's physical properties. Crusting can reduce the amount of water entering the soil, increase water runoff and erosion, and make it difficult for farmers to till the soil and for seedlings to emerge (72). Agriculture is "mining" the soil in many areas—removing more nutrients than it is putting back into the system through fallows, organic and mineral fertilizers, and rotations with nitrogen-fixing species.

These factors can significantly impair soil productivity and agricultural yields. The nature and extent of the impact varies by soil type and cultivation practices. FAO has estimated that without adequate conservation measures, the area of rainfed cropland in Africa will decline by 16.5 percent by the year 2000 because of land degradation. The loss of this land, plus the loss of soil quality on the remaining cropland, would lead to a loss of about 25 percent of Africa's land productivity (68).

Africa's three main types of vegetative cover—tropical rainforest, savannah woodland (or open forest), and rangeland–are all being

Table 3_3.—Summary of the Most Serious Environmental Degradation Problems by Region

Region	Arable Land	Grazing Land	Forest Land
Sudano-Sahelian Africa	Decline in nutrient levels in the soils Decline in soil physical properties Wind and water erosion	General degradation of vegetation's quality and quantity Wind erosion in sub-humid areas	Degradation of vegetation
Humid and Sub-Humid West Africa	Decline in nutrient levels in the soil Decline in soil physical properties Water erosion	Degradation of vegetation Wind erosion in sub-humid areas	Degradation of vegetation
Humid Central Africa	Degraded soil physical properties Degraded soil chemical properties		
Sub-Humid and Mountain East Africa	Water erosion Degradation of soil physical properties Degradation of soil chemical properties	Degradation in quality and quantity of vegetation Water erosion	Degradation of vegetation Water erosion
Sub-humid and Semi-Arid Southern Africa	Water erosion Degradation of soil physical properties Degradation of soil chemical properties	Degradation in quality and quantity of vegetation Wind erosion Water erosion	Degradation of vegetation Erosion

SOURCE U N Food and Agriculture Organization, *African Agriculture: The Next 25 Years, Annex II, The Land Resource Base* **(Rome, Italy' FAO, 1986).**

degraded or lost (4). Reliable data on deforestation is lacking for much of Africa, but an estimated 3.7 million hectares of forest are cleared every year (71). Tropical rainforests are being cleared primarily for agriculture and commercial logging, and the highest rates occur in the West African coastal countries. Savannah woodlands are being cleared for fuelwood, livestock grazing, farming, and construction materials. Rangelands are being cleared by overgrazing and the expansion of farming (4).

Significant resources are lost when land clearing is rapid and unmanaged. Trees, shrubs, and grasses help control erosion and maintain soil fertility. Trees are capable of recycling nutrients and reaching moisture at soil depths beyond the reach of most crop roots. In addition, trees and shrubs are essential to meet the fuelwood needs of low-resource agriculturalists. Wood is the primary fuel in Africa and deforestation is creating shortages. Data show that all of Sub-Saharan Africa, with the exception of the humid central region, will suffer a fuelwood deficit by 2010 (72). Fuelwood scarcity affects low-resource producers by increasing the time they must spend collecting it or the money they spend to purchase it. For example, the radius of fuelwood collection around Nouakchott, Mauritania expanded from 10 to 70 kilometers between 1970 and 1980 (4). Between 1970 to 1978, the price of fuelwood increased almost 10 percent per year in Ouagadougou, Burkina Faso (80). Wood deficits also can harm soil fertility because when wood is lacking farmers will use crop residues and animal manure for fuel instead of fertilizer (80).

OBSTACLES TO IMPROVING PRODUCTIVITY AND FOOD SECURITY

Low-resource agriculture currently is not meeting Africa's food security and agricultural development needs and productivity in low-resource agriculture is loosing a race with population growth. Most experts agree, however, that low-resource agriculture can be improved. This will require greater efforts by African governments, development assistance agencies, and the agriculturalists themselves in dealing with obstacles to enhancing low-resource agriculture. These obstacles are internal to the farming system, such as biophysical and socioeconomic constraints, as well as external to the farming systems. These latter factors include unsupportive policies, infrastructural weaknesses, and underdeveloped technical institutions.

Blophysical and Socioeconomic Constraints

One problem that confronts planners in Subsaharan Africa is that the average level of agricultural productivity is generally much lower than in other regions of the world. For example, cereal yields in Sub-Saharan Africa are about 50 percent less than yields in Latin America, and yields of roots, tubers, and pulses are 30 percent lower than yields in Asia and Latin America (9). This poor performance can be attributed primarily to biophysical and socioeconomic constraints within the farming systems.

Generally, African soils are low in fertility; rainfall is unpredictable in many areas and low across much of the continent. At least 44 percent of Africa is subject to drought conditions, 18 percent of the area has soil affected by mineral stress (toxicities and deficiencies), 13 percent of the soil is shallow, and 9 percent is affected by water stress. This accounting, while hampered by uncertain and sparse data, suggests that only 16 percent of Africa's total land area is without serious biophysical limitations for agriculture (65).

Over the past two decades, at least two-thirds of Africa's food production increases have been gained by expanding the area cultivated (55, 59]. Only one-third of the gains have come by increasing the output per hectare through intensification. Yield increases range from about 50 percent in eastern and southern Africa to virtually none in West Africa (59). The role of expansion onto uncultivated lands is decreas-

ing since cultivation is extending into increasingly marginal lands with lower production potential (42).

For Africa to meet its future food needs and avert serious environmental problems, a far greater proportion of its food production gains must come from intensification and yield improvements, and a smaller proportion from expanding the cropping area. Estimates by FAO, for example, suggest that by the year 2000 about one-half quarter of the necessary food production gains should come from yield increases, about one-quarter from increased cropping intensity, and about one-quarter from expanding the amount of arable land (66). This would require a dramatic shift in approach and presents numerous difficult challenges, although considerable regional variation exists in how rapid and how urgent such shifts need be (68). For example, agriculture in Rwanda has little room to expand in area, whereas in other countries, particularly in central Africa, population density and consequent pressure on land is still low (4,45).

Intensifying agricultural production in Africa presents many difficulties, particularly for Africa's resource-poor farmers and herders. First, agroecological factors can restrict the extent to which intensification is possible (5). For example, in low rainfall zones, opportunities to develop more intensive farming systems can be severely restricted by slow vegetative growth. Developing permanent cultivation systems in these regions, where possible, can seri-

Photo credit: Jerry Frank/U.N. Food and Agriculture Organization

This rice field is an experiment in agricultural intensification. The Liberian government, with assistance from the United Nations, is carrying out research and training personnel at the College of Agriculture and Forestry.

ously undermine the viability of pastoralist production systems in surrounding areas by denying herders access to essential dry season fodder. At the other climatic extreme–high rainfall areas—problems of soil leaching and acidification, as well as high incidence of pests and pathogens, can seriously limit more intensive cultivation and livestock rearing. Medium rainfall areas (i.e., 750 to 1,200 mm per year) and some areas of the humid highlands offer the highest potential for permanent intensified cultivation (5).

More intensive agriculture also generally involves a greater investment of labor and capital. This raises problems for resource-poor farmers who rely on household labor and have little money to invest in intensive practices. For example, more intensive production such as increasing the growing period relative to the fallow period can greatly increase the need for weeding and place excessive demand on household labor. Maintaining adequate soil fertility under conditions of intensified production may also require supplemental fertilizer use, requiring either an additional labor investment (e.g., rearing animals for manure) or additional cash to purchase fertilizer.

Adopting conservation practices to maintain soil fertility, such as building terraces, can also require considerable investment from the resource-poor farmer. Land tenure problems also complicate matters in low-resource agricultural systems. Farmers are generally unwilling to invest in the long-term benefits of conservation practices unless they know they will reap the future benefits. Finding sustainable technical and institutional answers that encourage the intensification of farming systems and yet are economically feasible and socially acceptable to resouce-poor farmers is a central challenge for development assistance in Africa.

Unsupportive Policies

National and donor policies often have not been designed to benefit low-resource agriculturalists; in some cases, policies have harmed resource-poor producers. Three types of these policies are discussed here: national policies regarding expenditures on agricultural development, agricultural pricing policies, and policies concerning the development of technology.

Expenditures on agricultural development in Africa reflect the relatively low importance agriculture has as an economic development strategy in the eyes of policymakers (2,58,64). Many African governments spend no more than 10 percent of their national budgets on agriculture even though an average of at least 50 percent of Africa's gross domestic product, employment, and foreign exchange depends on the agricultural sector (69). For example, while 70 percent of Botswana's labor force works primarily in agriculture, the government spends only 1 to 3 percent of its gross fixed investment in the sector. About 80 percent of Kenya's labor force works in agriculture, yet the government invests about 8 percent. Zimbabwe has the highest investment—12 percent in a country where 57 percent of its labor force works in agriculture (39).

National pricing policies have been criticized for their disincentive effects on agricultural production and rural income. Government marketing agencies that buy commodities from farmers regularly establish prices below their true market values. In this way they collect so-called "hidden taxes" from farmers, especially for export crops. This practice also enables governments to provide cheap food to urban populations (34, 78). Such policies can provide serious disincentives for production and make it unprofitable for producers to buy agricultural inputs. The institutions used to carry out such policies have also been criticized as ineffective, primarily the parastatal organizations that often control agricultural supplies and crop marketing.

The relative importance of pricing policy as a constraint on the enhancement of low-resource agriculture is not yet clear. Experts who believe pricing reforms are important argue that positive changes already have led to some significant increases in production and income (26). Other experts, however, are less convinced of the importance of pricing policies

relative to other development needs. These critics also contend that the benefits of pricing reforms have often gone to the minority of better-off farmers while bypassing, or in some cases hurting, the resource-poor agriculturalist (21)$_0$

Research and technical development policies have been criticized for being misguided and resulting in technological interventions that have failed to significantly improve low-resource agricultural systems. In some cases, interventions have actually upset the equilibrium of the old methods of land use without producing equally balanced new systems of farming (14). These problems arise because introduced technologies are often inappropriate for resource-poor farmers and herders (12)–whether for economic, social, managerial, or environmental reasons. Too often research efforts have focused on export crops or sophisticated systems that are out of reach for most farmers and herders and they have failed to account for the restricted access to and affordability of agricultural inputs (e.g., hybrid varieties, irrigation, and fertilizer).

Another problem has been that introduced technologies often ignore the reality of how African agriculture is actually practiced. For instance, farmers seeking to improve their intercropping systems necessarily suspect techniques designed for monocropping systems (19). The role of women in agricultural production, postharvest food processing, and household chores often has been neglected and technical interventions have been inappropriate, and thus unused, because they do not meet women's needs and priorities (33).

Infrastructural Weaknesses

Low-resource agricuhure suffers from infrastructural weaknesses that make it difficult to take advantage of improved technologies. These include inadequate *rural institutions* for saving and lending money, lack of rural transportation networks, and poorly developed distribution systems for providing agricultural inputs.

The official rural financial systems of Africa function poorly, at best (37) and are nonexistent in many isolated areas. Existing institutions often do not provide credit for producers to grow staple foods. They also deny credit to most women because usually women lack collateral. Official interest rates are often subsidized, making credit a bargain that is often monopolized by economic and political elites (49). Local investment opportunities are lost, then, because appropriate ways to promote rural-based savings and lending among resource-poor farmers, herders, and fishers are missing (38).

The costs of providing formal credit to resource-poor farmers are often a disincentive for formal financial institutions (70). While formal credit opportunities are few for resource-poor producers, informal sources do exist. Informal savings and loan associations, which are locally managed, socially regulated, and knowledgeable about the creditworthiness and financial needs of the rural poor, often serve rural populations not addressed by the formal sector. Given adequate incentives, many of these could grow to reach a larger population while providing credit at lower cost than formal banks (37, 49).

The lack of adequate transportation such as roads and rail systems throughout Africa is a major constraint to the delivery of inputs to farms and the transportation of food or other commodities to markets. The primary means of transporting agricultural products today is "headloading"—carrying them on one's head. In 1982, only 206,177 kilometers of roads existed in Africa's 14 landlocked countries. Among these countries, Zimbabwe had almost one-third of all roads and about 8,000 of the total 19,850 kilometers of paved roads (11).

Most of Africa's railroads were designed during the colonial period to link areas producing agricultural exports and minerals with the ports that would distribute them for the colonial powers. Lusaka, Zambia, is therefore linked by rail with Dar-es-Salaam, Tanzania; Uganda, Burundi, and Rwanda are linked with Mombasa, Kenya; and Bamako, Mali is linked with Dakar, Senegal, etc. Central Africa, because of

vast distances from a port, has no major rail links in spite of its agricultural potential. Because of low population densities in central Africa and other regions, the costs per capita to provide roads and other services are much greater than in other regions of the world (36).

The inadequacy of the systems for distributing and marketing external inputs is another constraint on low-resource agriculture. When external commercial inputs do arrive in rural Africa, they are often labeled and packaged improperly (36). Seed and fertilizer deliveries may not be synchronized and delays in the arrival of pesticides may make them less than effective (57). Africa ranks last in developing regions in the percentage of irrigated land, tractors per 10,000 hectares, and fertilizer use per hectare (table 3-4). If commercial inputs are to be used by more agriculturalists in Africa, better delivery organizations and a better transport infrastructure are essential.

Underdeveloped Technical Institutions

Low-resource agriculture in general, will need to become more intensive to meet the food security needs while balancing the need to maintain the natural resource base. This change will, in part, depend on technical developments and the spread of their use among agriculturalists. Total funding for agricultural research has been declining in Sub-Saharan Africa. Expenditures by national governments for agricultural research decreased $80 million between 1980 and 1984, from $465 million to $385 million (46).

Table 3-4.—Modern Input Use in Africa, Asia, and South America, 1977

Area	Percentage of irrigated land	Tractors per 10,000 hectares	Fertilizer used per hectare
	Percent	Number	Kilograms
Africa	1,8	7	4,4
Asia ...	28.0	45	45.4
South America	6.1	57	38.8

SOURCES: **U.N. Food and Agriculture Organization,** *Production* **Yearbook, and** *Fertilizer Yearbook* **(Rome: 1978). Cheryl Christensen, et al.,** *Food Problems and Prospects in Sub-Saharan Africa: The Decade of the 1980's,* **Foreign Agricultural Research Report No. 166 (Washington, DC: U.S. Department of Agriculture, Economic Research Service, August 1981),**

Also, research priorities often do not reflect food security needs. For example, in 1983 British foreign aid funding for tobacco research in Malawi was about twice as much as it was for millet research (77). Cassava is a staple food in many parts of Africa but only Nigeria (with a $2.7 million investment) and Ghana (with a $0.9 million investment) spent at least $50,000 on cassava research in 1976. Although the International Institute of Tropical Agriculture (IITA) has made some advances in cassava research, national programs primarily are responsible for developing varieties adapted to and accepted by local farmers (39). These programs often do not have adequate budgets or rank high enough in national governments' priorities to have a major impact on food security needs.

Extension systems in African countries also face many problems. They generally lack staff, supplies, and technical support, and inadequate communication exists between researchers, extensionists, and farmers. They also suffer from a lack of appropriate and profitable technologies to transfer. Some critics argue, then, that extension's problems originate with the lack of research and that, under existing agricultural budgets, research deserves a higher priority (32).

Another problem with most extension services is that they focus on providing information and inputs for export crops rather than food crops. In addition, the approaches used are generally "topdown," with the information flow in one direction—from the researcher through the extension agent to the male farmer (69). Women, the major food producers in many regions, often are not provided with relevant services. Non-formal education for African women most often covers their non-income generating activities, including home economics and nutrition (6), but they have limited access to training activities dealing with income-related activities such as cooperatives, agricultural production, and animal husbandry. Considering the major role of women as food producers and caretakers of livestock, this is a serious failure of the system.

Ensuring good staff for extension, research, and other agricultural services is another prob-

lem (36). Low-quality facilities, low salaries, undesirable living conditions, and the lack of status associated with working for traditional farmers are not attractive to trained personnel (36). Research staff turnover rates are high: at the Nigerian Institute for Agricuhure, for example, staff turnover was about 80 percent between the 1960s and 1970s (46). In addition, governments spent three to ten times more for skilled staff such as researchers in Africa than in Asia in part because of a reliance on higher-salaried foreign scientists. These high costs make it difficult for African countries to expand national research systems.

A substantial increase in funding for research and personnel occurred between 1970 and 1980 (table 3-5). However, since 1980 a general decline in research expenditures has occurred (29). At the same time the number of scientists involved has grown, compounding the impact of recent budget declines in terms of level of support per scientist.

In many African countries, a high proportion of budgets cover salaries versus operations. This can be a serious obstacle to producing needed high-quality research and technology development. For example, some institutions allocate only 5 percent of their budgets to operations and maintenance, compared to a desirable figure of at least 30 percent (29). This places serious limitations on the funds available to get researchers into the field. As long as researchers are isolated from agriculturalists, questions will arise regarding their ability to address the on-farm problems of low-resource agriculture effectively.

Removing these all-too familiar obstacles will not be easy. The process is likely to take at least a generation, even if significant increases in resources were available today. Heightening the challenge is the realization that African countries will have double the number of people to feed and employ within the next several decades. The industrial and urban sectors cannot effectively absorb or provide for large portions of these people. The continuing dependence on rural employment and local food production by large numbers of Africans is thus inevitable. However, signs of decline in African agriculture underscore the urgency of better addressing the problems and potential of Africa's largest group of farmers, herders, and fishers. The following chapters outline one approach to enhancing low-resource agriculture in Africa.

Table 3-5.—Level of Support for Agricultural Research in Different Regions

	Expenditures (in millions of constant 1980 U.S. dollars)			Scientist Years		
	1959	1970	1980	1959	1970	1980
Western Europe	275.0	918.6	1,489.6	6,251	12,547	19,540
North America	668.9	1,221.0	1,335.6	6,690	8,575	10,305
Oceania	91.6	264.0	386.8	1,759	3,113	3,302
Latin America	79.6	216.0	462.6	1,425	4,880	8,534
Africa	119.1	251.6	424.8	1,919	3,849	8,086
North Africa	20.8	49.7	62.0	590	1,122	2,340
West Africa	44.3	91.9	205.7	412	952	2,466
East Africa	12.7	49.2	75.2	221	684	1,632
Southern Africa	41.3	60.8	81.8	698	1,091	1,650
Asia	261.1	1,205.1	1,797.9	11,418	31,837	46,656

SOURCES: U.N. Food and Agriculture organization, African Agriculture: The Next 25 Years, Annex Ill: *Raising Productivity* **(Rome: Italy, FAO, 1986). M.** Judd J. Boyce and R. Evenson, **"Investing in Agricultural Supply: The Determinants of Agricultural Research and Extension Investment,"** *Economic and Cultural Change, vol. 75,* **October 1986, pp. 77-113. (Courtesy of the University of Chicago Press).**

CHAPTER 3 REFERENCES

1. Andrews, David J., "Millet Breeding for Low-Resource Agriculture in Africa," contractor report prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December *1987).*
2. Asante, S. K. B., "Food as a Focus of National and Regional Policies in Contemporary Africa," Arthur Hansen and Della E. McMillan (eds.), *Food in Sub-Saharan Africa* (Boulder, CO: Lynne Riener Publishers, Inc., *1986),* pp. 11-24.
3. Bamela-Engo, Ruth, "Food Security: How To Ensure That Famine Won't Recur in Africa," *VITA News,* January *1987,* pp. *9-11.*
4. Berry, Leonard, "Africa: An Environmental Case Study" (Worcester, MA: Clark University/ SARSA, **1986).**
5. Binswanger, H. P., and Pingali, P, L., "The Evolution of Farming Systems and Agricultural Technology in Sub-Saharan Africa," Vernon W. Ruttan and C.E. Pray (eds.), *Policy for Agricultural Research* (Boulder, CO: Westview Press, *1987),* pp. *283-318.*
6. Blumberg, Rae Lesser, "Females, Farming and Food: Rural Development and Women's Participation in Agricultural Production Systems," Barbara Lewis (cd.), *Invisible Farmers: Women and the Crisis in Agriculture* (Washington, DC: Women in Development Office, Agency for International Development, 1981).
7. Brumby, P. J., and Trail, J. C. M., "Animal Breeding and Productivity Studies in Africa, " *ILCA Bulletin, No. 23,* January *1986,* pp. *23-27.*
8. Campbell, B., "The Use of Wild Fruits in Zimbabwe," *Economic Botany,* vol. 41, No. 3, July-September *1987,* pp. *375-386.*
9. Christensen, Cheryl; Dommen, Arthur; Horenstein, Nadine; Pryor, Shirley; Riley, Peter; Shapouri, Shahla; and Steiner, Herb, *Food Problems and Prospects in Sub-Saharan Africa: The Decade of the 1980's,* Foreign Agricultural Economic Report No. 166 (Washington, DC: U.S. Department of Agriculture, August *1981).*
10. Cleave, John, *African Farmers: Labor Use in the Development of Smallholder Agriculture* (Washington, DC: Praeger Publishers, 1974).
11. Clute, Robert E., "The Role of Agriculture in African Development," *African Studies Review,* vol. *25, No, 4,.* December *1982,* pp. 1-20.
12. Collinson, M., "Eastern and Southern Africa, " John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, *1987),* pp. *78-96.*
13. Dalrymple, Dana, *Development and Spread of High-yielding Rice Varieties in Developing Countries* (Washington, DC: Bureau for Science and Technology, U.S. Agency for International Development, *1986),*
14. De Wilde, John, et al., *Experiences With Agricultural Development in Tropical Agriculture, vol. 1* (Baltimore, MD: The Johns Hopkins University Press, *1967),* p. *25.*
15. Doswell, Christopher, unpublished estimates compiled from U.N. Food and Agriculture Organization, International Institute for Tropical Agriculture, and International Maize and Wheat Improvement Center sources, April *1986.*
16. Dyson-Hudson, N. "Adaptive Resource Use Strategies of African Pastoralists," In F. DiCastri, F.W.G. Baker, and M. Hadley (eds.), *Ecology in Practice Part I: Ecosystem Maintenance* (Dublin: Tycooly International Publishing Limited, 1984), pp. 262-273.
17. Eicher, C, K., and Baker, D., *Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey,* MSU International Development Paper No. 1 (East Lansing, MI: Agricultural Economics Department, Michigan State University, 1982).
18. Fleuret, Anne, "The Role of Wild Foliage Plants in the Diet: A Case Study From Lushoto, Tanzania," *Ecology of Food and Nutrition,* vol. *8, 1979,* pp. *87-93.*
19. Francis, Charles, "Challenges of Intercropping: Policy Issues," contractor paper prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987),
20. Galaty, J, G., and Aronson, D. R., "Research Priorities and Pastoralist Development: What Is To Be Done?" J.G. Galaty, D. Aronson, P.C. Salzman, and A. Chouinard (eds.), *The Future of Pastoral Peoples* (Ottawa: International Development Research Centre, 1981), pp. 16-26.
21. Ghai, Dharam, and Smith, Lawrence, "Food Price Policy and Equity," J. Mellor, C. Delgado, and M. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, 1987), pp. 278-289.
22. Gryseels, G., and Anderson, F.M., *Research on Farm and Livestock productivity in Central Ethiopian Highlands: Initial Results, 1977-1980,*

ILCA Research Report No. 4 (Addis Ababa: International Livestock Centre for Africa, December 1983).
23. Guthrie, C., "The African Environment, " Arthur Hansen and Della E. McMillan (eds.), *Food in Sub-Saharan Africa* (Boulder, CO: Lynne Rienner Publishers, Inc., 1986), pp. 82-106.
24. Haggblade, Steve, Hazell, Peter, and Brown, James, *Farm/Non-Farm Linkages in Rural Sub-Saharan Africa: Empirical Evidence and Policy Implications,* World Bank Discussion Paper, Report No. ARU 67 (Washington, DC: World Bank, May 1987).
25. Hahn, S. K., "Tropical Root Crops: Their Improvement and Utilization," presented at a conference organized by the Commonwealth Agricultural Bureau on "Advancing Agricultural Production in Africa," held Feb. 13-17, 1984, Arusha, Tanzania, IITA Conference Paper 2 (Ibadan, Nigeria: International Institute of Tropical Agriculture, 1984).
26. Haykin, Stephen, *Policy Reform Programs in Africa: A Preliminary Assessment of Impacts* (Washington, DC: Africa Bureau, U.S. Agency for International Development, March 1987}.
27. Hill, Walter A., and Bonsi, Conrad, "Root Crop Breeding, " contractor paper prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987).
28. International] Livestock Center for Africa (ILCA), *ILCA Annual Report 1983: Improving Livestock and Crop-Livestock Systems in Africa,* Addis Ababa, Ethiopia, 1983.
29. International Service for National Agricultural Research and SPAAR Working Group for Preparation of Guidelines for National Agricultural Research Strategies in Sub-Saharan Africa, *Guidelines for Strengthening National Agricultural Research Systems in Sub-Saharan Africa,* Special Program for African Agricultural Research (SPAAR) (Washington, DC: The World Bank, May 1987).
30, Jahnke, H. E., *Livestock Production Systems and Livestock Development in Tropical Africa* (Kiel, FRG: Kieler Wissenschaftsverlag Vauk, 1982).
31. Jiggins, Janice, Vrouwen en Voedselstra-tegiecn [Women in Food Strategy), unpublished report, November 1985.
32. Judd, M., Boyce, James, and Evenson, Robert, "Investing Agricultural Supply: The Determinants of Agricultural Research and Extension Investment," *Economic Development and Cultural Change,* vol. 35, No. 1, October 1986, pp. 77-113.
33. Kumar, Shubh K., "Women's Role and Agricultural Technology," John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, 1987), pp. 135-147.
34. Lancaster, Carol, "Existing Models of Development Assistance to Low-Resource Agriculture in Africa, " contractor report prepared for the Office of Technology Assessment (Springfield VA: National Technical Information Service, December 1987).
35. Langemann, J., *Traditional African Farming Systems in Eastern Nigeria: An Analysis of Reaction to Increasing Population Density* (Munich, FRG: Weltforum Verlag, 1977).
36. Lele, Urea, "Rural Africa: Modernization, Equity, and Long-Term Development, " ***Science,*** Feb. 6, 1981, pp. 547-53.
37, Leonard, David, "Putting the Farmer in Control: Building Agricultural Institutions, " Robert J. Berg and Jennifer Seymour Whitaker (eds.), *Strategies for African Development* (Berkeley, CA: University of California Press, 1986), pp. 184-24.
38. Leonard, David, Associate Professor, Department of Political Science, University of California, Berkeley, personal communication, 1987,
39. Lipton, Michael, "Research and the Design of a Policy Frame for Agriculture," Tore Rose (cd.), *Crisis and Recovery in Sub-Saharan Africa* (Paris: Organization for Economic Cooperation and Development, 1985), pp. 78-95.
40. Little, Peter, "Land Use Conflicts in the Agricultural Pastoral Borderlands: The Case of Kenya, " Peter Little, et al, (eds.), *Lands at Risk in the Third World* (Boulder, CO: Westview press, 1987), pp. 195-212.
41. Mackie, Arthur B., *The U.S. Farmer and World Market Development* (Washington, DC: U.S. Department of Agriculture, October 1983).
42. Matlon, Peter J., "The West African Semiarid Tropics," John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, 1987), pp. 59-77.
43. McGee, Daniel, "Subsistence Strategies and Systems of Land Use in Africa, " Art Hansen and Della E. McMillan (eds.), *Food in Sub-Saharan Africa* (Boulder, CO: Lynne Rienner Publishers, Inc., 1986), pp. 129-135.
44. McGlothlen, Michael E., Goldsmith, Paul, and Fox, Charles, "Undomesticated Animals and Plants," Art Hansen and Della E. McMillan

(eds.), *Food in Sub-Saharan Africa* (Boulder, CO: Lynne Rienner Publishers, Inc., 1986), pp. 222-238.
45. McMillan, Della, "Government Assisted Land Settlement: Status and Potential in African Low-Resource Agriculture," contractor report to the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987).
46. Mellor, John, "IFPRI Notes: Accelerating Food Production in Sub-Saharan Africa" (Washington, DC: IFPRI, 1986).
47. Mellor, J., Delgado, C., and Blackie, M., "Priorities for Accelerating Food Production in Sub-Saharan Africa," John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, 1987), pp. 353-375,
48. Miller, F., and Mann, J., "Technical and Policy Papers Series: Sorghum Breeding," contractor report prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987).
49. Miracle, Marvin, Miracle, Diane, and Cohen, Laurie, "Informal Savings and Mobilizations in Africa," *Economic Development and Cultural Change,* vol. 28, No. 4, July 1980, pp. 701-724.
50. Moock, J.L. (cd.), *Understanding Africa's Rural Households and Farming Systems* (Boulder, CO: Westview Press, 1986).
51. Moris, Jon, "Indigenous Versus Introduced Solutions to Food Stress," IFPRI/FAO/AID Workshop on Seasonal Causes of Household Food Insecurity, Policy Implications and Research Needs, 1985.
52. Mukwonye, Uzo, International Fertilizer Development Center-Africa, Lome, Togo, personal communication to the Office of Technology Assessment, May 1987,
53. National Research Council, *Fisheries Technologies for Developing Countries* (Washington, DC: National Academy Press, 1988).
54. Okigbo, Bede, "Alternatives to Shifting Agriculture," *Ceres*, vol. 14, November-December 1981, pp. 41-45.
55. Okigbo, Bede, Deputy Director, International Institute for Tropical Agriculture, Ibadan, Nigeria, personal communication, 1987.
56. Okigbo, B.N. and Greenland, D. J., "Intercropping Systems in Tropical Africa," R.I. Papendick, P.A. Sanchez, and G.B. Triplett (eds.), *Multiple Cropping*, ASA Publication No 27 (Madison, WI: American Society of Agronomy, 1976), pp. 63-101.
57. Olayide, S.0., and Idachaba, Francis S., "Input and Output Marketing Systems: A Nigerian Case," John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The John Hopkins Univ. Press, 1987), pp. 173-198.
58. Pallangyo, E. P., and Odero-Ogwel, L. A., "The Persistence of the Food and Agriculture Crisis in Africa," Adedeji, Adebayo and Timothy M, Shaw (eds.), *Economic Crisis in Africa: African Perspectives on Development Problems and Potentials* (Boulder, CO: Lynne Rienner Publishers, Inc., 1985), pp. 169-200.
59. Pauline, Leonardo, "The Evolving Food Situation," John W. Mellor, Christopher L. Delgado, and Malcolm J. Blackie (eds.), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: The Johns Hopkins University Press, 1987), pp. 23-38,
60. Pratt, D. J., "Ecology and Livestock," J.R. Simpson and P. Evangelou (eds.), *Livestock Development in Sub-Saharan Africa* (Boulder, CO: Westview Press, 1984), pp. 21-41.
61. Raintree, J, B., and Warner, K., "Agroforestry Pathways for the Intensification of Shifting Cultivation," *Agroforestry Systems,* vol. 4, 1986, pp. 39-54.
62. Schneider, H., "Livestock as Food and Money," J. Galaty, D. Aronson, P. Salzman, and A. Chouinard (eds.), *The Futures of Pastoral Peoples* (Ottawa, Canada: International Development Research Centre, 1981).
63. Simpson, James R., and McDowell, Robert E., "Livestock in the Economies of Sub-Saharan Africa," Art Hansen and Della E. McMillan (eds.), *Food in Sub-Saharan Africa* (Boulder, CO: Lynne Rienner Publishers, Inc., 1986), pp. 207-221.
64. Staatz, John, "Low-Resource Agriculture in Sub-Saharan Africa: The Potential of Low-Resource Agriculture in African Development," contractor report prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987).
65. Swaminathan, M. S., *Sustainable Nutrition Security for Africa: Lessons From India,* The Hunger Project Papers, No. 5, October 1986.
66. U.N. Food and Agriculture Organization, *Agriculture: Toward 2000* (Rome:1981).

67. U.N. Food and Agriculture Organization, "Potential Population-Supporting Capacities of Lands in the Developing World," Rome, 1982.
68. U.N. Food and Agriculture Organization, *Land, Food and People*, Rome, 1984.
69. U.N. Food and Agriculture Organization, *African Agriculture: the Next 25 Years, Main Document,* Rome, 1986.
70. U.N. Food and Agriculture Organization, *African Agriculture: the Next 25 Years. Annex I. Socio-Economic and Political Dimensions,* Rome, 1986.
71. U.N. Food and Agriculture Organization, *African Agriculture: the Next 25 years. Annex II. The Land Resource Base,* Rome, 1986,
72. U.N. Food and Agriculture Organization, *African Agriculture: the Next 25 years. Atlas of African Agriculture*, Rome, 1986.
73. U.N. Food and Agriculture Organization, *Natural Resources and the Human Environment for Food and Agriculture in Africa,* FAO Environment and Energy Paper, No. 6, Rome, 1986.
74. U.N. Food and Agriculture Organization, "Role of Roots, Tubers and Plantains in Food Security in Sub-Saharan Africa, " Committee on World Food Security, Eleventh Session, Rome, Apr. 9-16, 1986.
75 U.S. Department of Agriculture, Economic Research Service, "The Role of Low-Resource Agriculture in Africa, " contractor reports prepared for the Office of Technology Assessment (Springfield, VA: National Technical Information Service, December 1987).
76. Varmoer, Alexander P., "Commentary on Defining the Problem, " John W. Mellor, Christopher L. Delgado and Malcolm J. Blackie (eds), *Accelerating Food Production in Sub-Saharan Africa* (Baltimore, MD: Johns Hopkins University Press, 1987), pp. 53-56.
77. Walker, Brian, *Authentic Development,* Headline Series, No. 274 (New York, NY: Foreign Policy Association, 1985),
78, World Bank, *Accelerated Development in Sub-Saharan Africa: An Agenda for Action,* Washington, DC, October 1981.
79. World Bank, *Poverty and Hunger: Issues and Options for Food Security in Developing Countries,* Washington, DC, February 1986.
80. World Bank, *Population Growth and Policies in Sub-Saharan Africa,* World Bank Policy Study, Washington, DC, August 1986,
81. World Bank, *World Development Report 1986 [New* York, NY: Oxford University Press, 1986),
82. World Bank, *West Africa Agricultural Research Review: World Bank 1985-86* (Washington, DC: World Bank Western Africa Projects Department, Feb. 28, 1987).
83. World Resources Institute, *World Resources* 1986 (New York, NY: Basic Books, Inc., 1986).