draw on in-depth studies of maize production, processing, and marketing completed within the past five years. All of the studies are based on extensive fieldwork, including surveys of thousands of farmers. The results of these studies provide a unique opportunity to draw implications for future food production strategies, policy reforms, and donor assistance.

The third part of the book examines technologies, institutions, and policies to increase food production in Africa in the twenty-first century. Chapter 9 reviews past achievements and future challenges related to the generation and diffusion of technology through research and extension systems. The next chapter discusses the need to take account of consumer preferences when setting priorities for maize research. Chapter 11 focuses on a critical issue in much of Africa's maize belt: the search for cost-effective and sustainable approaches to increasing soil fertility.

Government monopolies are rapidly being replaced by new forms of public and private partnerships and new indigenous and multinational seed companies in eastern and southern Africa. These encouraging institutional innovations are discussed in Chapter 12 on the maize seed industry. Chapter 13 examines the contentious issues surrounding the development of efficient fertilizer distribution systems. Chapter 14 pulls together the burgeoning literature on maize marketing, processing, and pricing to shed light on the complex issues of public grain marketing monopolies. In eastern and southern Africa, most of these monopolies were established during the world depression in the 1930s to regulate the pricing and distribution of maize. In the wake of the policy reforms that have occurred over the past decade, the appropriate roles of government and the private sector in marketing maize and other food crops are evolving and subject to vigorous debate.

In part four, we draw together the main findings from the country studies and technical chapters to identify the crucial decisions that must be taken to increase maize production in Africa in the next 20 years. Although these findings are based on the analysis of data for only one crop, we believe many of the conclusions and generalizations are relevant to the broader issues of increasing food production in Africa.

Note

1. In 1992, the per capita calorie consumption of food staples in sub-Saharan Africa was as follows: maize, 302; cassava, 299; sorghum, 162; rice, 162; millet, 123; wheat, 120; sweet potatoes, 107; and plantain, 57 (FAO, various years).

2

Evolution of the African Maize Economy

Derek Byerlee & Paul W. Heisey

Maize was a relatively minor food crop in Africa in 1900, but today it is the continent's most important food crop. This chapter first briefly traces the evolution of maize in Africa during the twentieth century and updates the historical description provided in Marvin Miracle's *Maize in Tropical Africa* (1966). The bulk of the chapter is devoted to an analysis of broad trends in maize production, yields, and consumption over the past thirty years, based on secondary statistics. Given the poor quality of statistics in Africa, the conclusions must be treated with caution. Some countries undoubtedly have fairly reliable statistics on food production and consumption, but in many other countries civil war and financial constraints have produced gaps and inconsistencies in the data.

Historical Background

Maize arrived in Africa in the course of the sixteenth century, most likely through Portuguese traders who stopped along both the western and eastern coasts. From the coast, maize slowly moved inland through various routes, particularly through the incursions of slave traders, who valued maize as a storable and easily processed grain (Miracle 1966). Most farmers had little to do with the new crop, however, and for centuries maize was an important food staple in only a few pockets of Africa.

Maize's transition to a major crop occurred in Kenya during World War I, when the colonial government encouraged farmers to plant maize for the war effort. At the same time, a serious disease epidemic in the traditional food crop, millet, led to famine, and stocks of millet seed were consumed rather than saved for planting. By providing farmers with seed of a late-maturing white maize variety, the colonial government sped the transition from a millet- to a maize-based food economy. After the war, the development of export markets encouraged maize production, and by the

1930s maize was established as the dominant food crop in much of Kenya and Tanzania (Taylor 1969; Gerhart 1975).

In southern Africa (outside of South Africa), commercial maize production began when white settlers moved into the area in the late 1890s. Maize became a major crop for commercial farmers, especially because of the increasing demand for grain in the mining areas. Colonial governments found it attractive to promote maize for African wage earners because it was easy to process compared to the traditional staples, millet and sorghum (Miracle 1966). Finally, the booming starch market in England provided an outlet for white maize exports from Zimbabwe (Masters 1994).

Maize gradually became a staple of the African population in eastern and southern Africa, beginning with those who were most exposed to commercial activities. By the 1930s, maize was important in smallholder agriculture as both a subsistence and a cash crop. The expanding infrastructure, especially the railways, further encouraged the expansion of maize. The nearly complete changeover in the diets of millions of Africans from traditional sorghum and millet to maize in less than two generations represents a remarkable revolution in food production and consumption patterns. In Malawi, 80% of the cultivated area is now planted to maize, though the crop was virtually unknown a century ago.

In most of western Africa, maize never reached the level of importance it acquired in eastern and southern Africa, but production grew sufficiently for western Africa to become a net exporter of maize in the early part of the twentieth century. The most dramatic expansion of maize production in western Africa has occurred over the past two decades in the savanna areas, as improved technology, development of rural roads, and urban demand fueled a rapid increase in maize area (Kennedy and Reardon 1994).

Trends in Food Production and Consumption

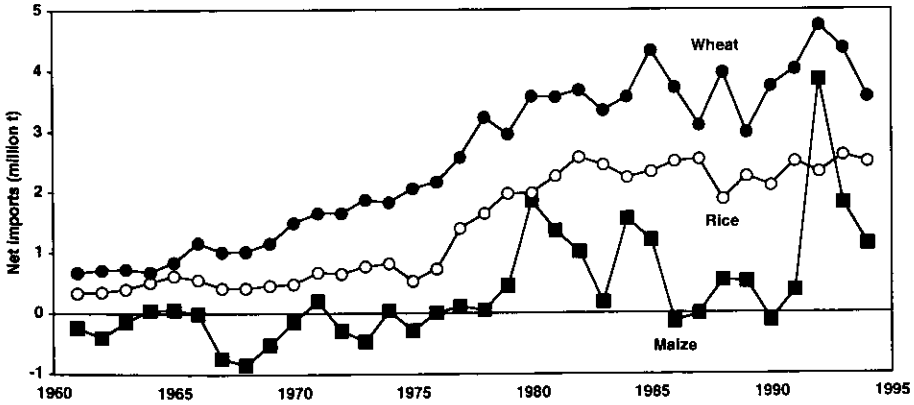
The role of maize in Africa's food economy must be viewed against overall trends in food production and consumption across the continent. The food production trends have been well documented. The index of per capita food *production*, stagnant in the 1960s, began moving steadily downward in the 1970s. This trend may have bottomed out around 1985, but overall the index is considerably lower in Africa than in South Asia, where per capita food production has risen steadily since the green revolution of the 1960s. The trend in per capita calorie *consumption* in Africa has been less pronounced, showing only a slight decline from the 1960s. Shortfalls in domestic food production have been made up through a growing

reliance on imports, especially of rice and wheat, which surged in the 1970s (Figure 2.1). For maize, Africa has shifted from being a net exporter in the 1960s to a net importer in the 1990s. Maize imports have been highest in drought years, especially 1992, when maize imports exceeded rice imports.

All recent projections show a widening gap between food supply and demand in Africa. Africa imports about 10 million tonnes of food each year, almost half of it under various food aid programs. With current trends in production and no change in per capita consumption, this gap is projected to widen substantially by 2020.

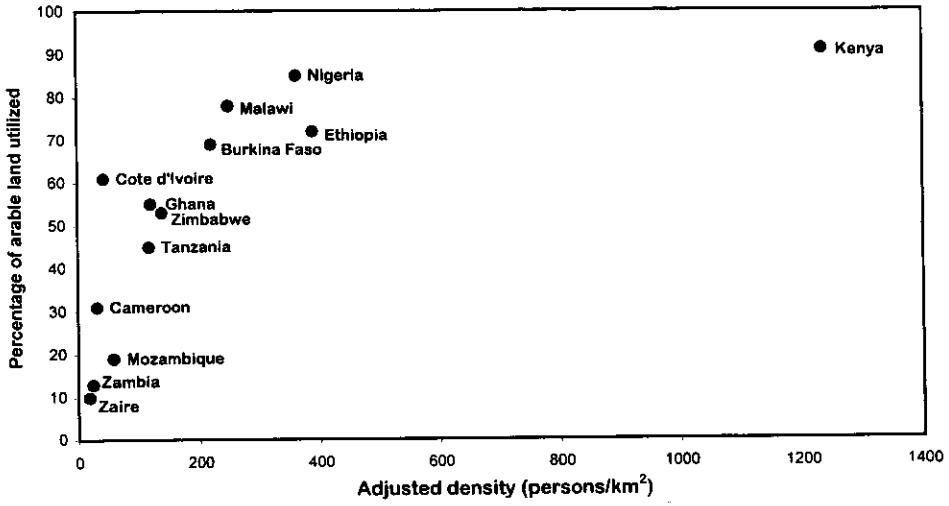
Aggregate indicators on the input side also point to the difficult situation confronting African food producers. The amount of arable land per agricultural worker has diminished steadily with population growth, although the amount of available land varies substantially from one country and region to another. Aggregate data on population density, however, can be misleading as an indicator of land scarcity, because large areas in Africa are marginal for agriculture. Figure 2.2 shows the distribution of countries with respect to population per unit of land, standardized for production potential following Binswanger and Pingali (1988). The figure also shows cultivated land as a percentage of estimated potential arable area, based on Cleaver and Donovan (1995). By both measures, several countries—particularly Nigeria, Kenya, and Ethiopia—now surpass major Asian countries in intensity of land use. At the same time, several countries—such as

Figure 2.1 Africa: Net Imports of Wheat, Rice, and Maize



Source: Computed from FAO data tapes.

Figure 2.2 Africa, Selected Countries: Adjusted Population Density and Proportion of Arable Land Utilized, Mid-1980s



Source: Computed from Binswanger and Pingali (1988) and FAO data tapes.

Zaire, Zambia, and Mozambique—have substantial potential to increase the area under cultivation.

Increasing intensification of land use is characteristic of most developing regions undergoing rapid population growth. In most regions of the developing world, intensification has been accompanied by the use of land-saving technologies, especially improved seed-fertilizer and irrigation technologies. But in Africa intensification has lagged. Although farmers' use of modern varieties increased rapidly in the 1980s, especially for maize (an estimated 40% of the area is now planted to improved varieties; see Chapter 9), fertilizer use per hectare is very low and has stagnated since about 1980. In 1989, fertilizer use per hectare on rain-fed land in India was more than three times that in Africa. Given the breakdown of the bush-fallow system under population pressure and soil degradation resulting from the mining of soil nutrients, the limited use of fertilizer in Africa is a critical policy issue in increasing food production.

A final indicator of the precarious state of African agriculture is the steady decline in agricultural output per worker over the past 30 years, the result of slow growth in output combined with increasing population pressure (Pardey and Roseboom 1991). Whereas most regions of the developing world have enjoyed increases in agricultural output both per worker and per hectare, output per hectare in Africa has remained unchanged and output per worker has fallen.

Distribution of Maize Production in Relation to Ecological Regions

Annual maize production in Africa (excluding South Africa) averages about 26 million tonnes on more than 20 million hectares (Table 2.1). In global terms, Africa is a relatively small producer; by comparison, the U.S. state of Iowa alone harvests almost 50 million tonnes of maize. Seven African countries produce more than 1 million tonnes of maize each year; together, they account for over 70% of the maize produced in Africa. (Five of these seven are included as case studies in this book; Ethiopia and Tanzania are the exceptions.)

A large area of Africa is classified by the Food and Agriculture Organization (FAO) as suitable or very suitable for maize production (Figure 2.3). The maize belt extends from southern Africa through eastern Africa and across the savanna of western Africa. The maize belt is bounded on

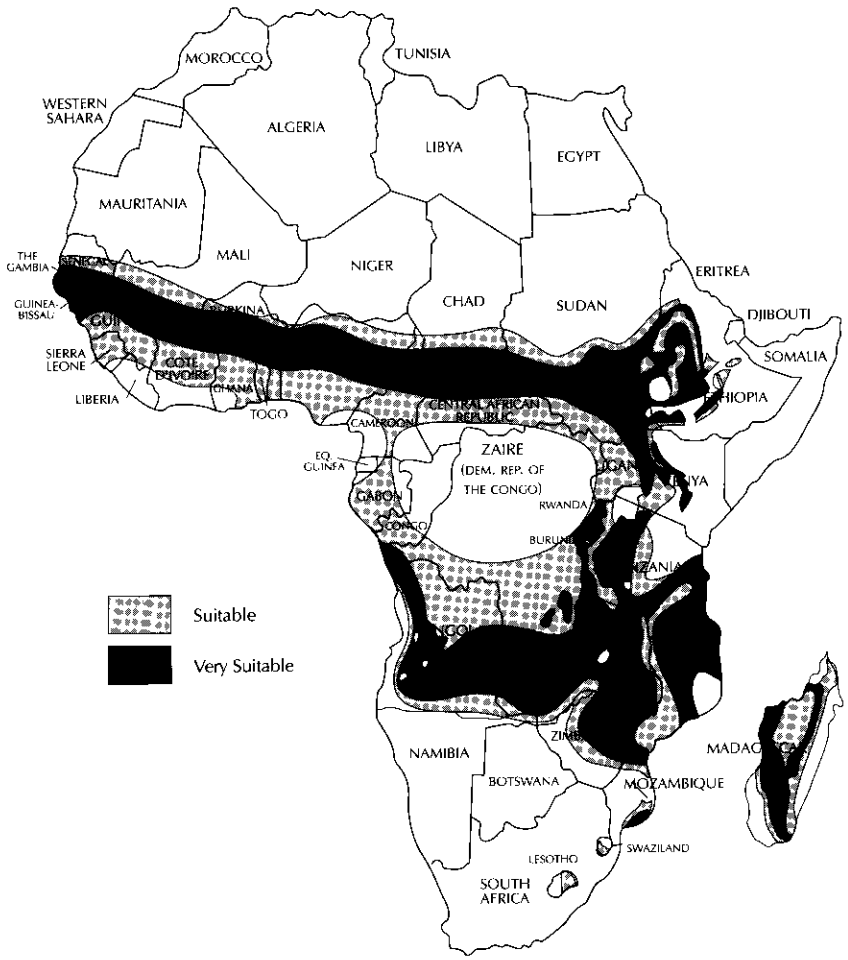
Table 2.1 Africa: Major Trends and Distribution of Maize Production

	Western and Central Africa	Eastern Africa	Southern Africa	All of Africa
Maize area, 1993–1995 (million ha)	10.2	5.2	5.2	20.6
Maize yield, 1993–1995 (t/ha)	1.2	1.6	1.1	1.2
Maize production, 1993–1995 (million t)	11.9	8.2	5.7	25.8
Regional share of maize production (%)	46	32	22	100
Percentage of area in region that is[a]				
Lowland	90	12	14	28
Mid-altitude	8	47	85	54
Highland	2	41	1	18
Total	100	100	100	100
Growth in maize area (%/yr) in[b]				
1975–1985	2.3	–0.4	0.4	0.6
1985–1995	3.2	0.7	0.1	1.3
1975–1995	2.6	1.4	0.6	1.6
Growth in maize yield (%/yr) in[b]				
1975–1985	1.7	0.9	–1.1	0.2
1985–1995	1.4	0.5	–4.0	–0.6
1975–1995	1.9	0.9	–1.2	0.5
Growth in maize production (%/yr) in[b]				
1975–1985	4.1	0.5	–0.8	0.8
1985–1995	4.6	1.1	–3.9	0.7
1975–1995	4.5	2.3	–0.5	2.0

Notes: a. Lowland areas are less than 900 meters above sea level (masl); mid-altitude areas, 900–1,800 masl; and highland areas, above 1,800 masl.

b. Growth rates for western and central Africa exclude Nigeria. Growth rates for southern Africa exclude Angola, Mozambique, and South Africa. Growth rates for all of Africa exclude all four countries. Although South Africa is the largest maize producer in Africa, accounting for about one-third of total production, more than 85% of the maize produced in South Africa is grown on large commercial farms. Since we generally focus on small-scale producers, South Africa is not included here.

Figure 2.3 Areas of Sub-Saharan Africa Classified as Suitable for Maize Production



Source: USDA, 1981

one side by the forest zone, where reduced solar radiation limits maize production, and on the other side by semiarid areas, where a short growing season and frequent drought favor sorghum and millet. Throughout this century, however, maize has steadily pushed into the drier areas, displacing the traditional grains. Much of the recent expansion of maize area has occurred in the semiarid areas, especially in eastern and southern Africa.

The International Maize and Wheat Improvement Center (CIMMYT) uses three basic criteria to classify the range of production environments in which maize is grown: altitude, maturity, and grain color and texture.

- Altitude (as a proxy for temperature): Generally, three categories are used for altitude: lowland tropical areas, which are less than 900 meters above sea level (masl); mid-altitude areas, at 900–1,800 masl; and highland areas, above 1,800 masl.
- Maturity: The amount of rainfall and its distribution determine the length of the growing season and the appropriate maturity class for maize (early, intermediate, and late).
- Grain color and texture: Most maize produced for food in Africa is white, although in parts of western Africa yellow maize is grown. Commercial farmers in Zimbabwe produce yellow maize for animal feed. The preferred grain texture varies from relatively soft dent to flint.

The overall distribution of maize by the major altitude environments is shown in Table 2.1. Clearly, there is a major difference between western and central Africa, where 90% of the maize area is in the lowland tropics, and eastern and southern Africa, where 47% of the maize is grown in the mid-altitude areas and 41% is produced in the highlands (mostly in eastern Africa). Maize yields are significantly higher in the mid-altitude and highland environments, in part because of the use of improved technology. Throughout Africa, maize is produced in areas where rainfall is relatively favorable, although some favorable areas are subject to infrequent but very serious droughts.

In eastern and southern Africa, a further important characteristic for distinguishing among maize production systems is the type of farmer producing maize (CIMMYT 1990). The most important category in terms of production is the medium-scale farmer, cultivating 3–10 ha of land using animal power. The second-most important type of farmer, the small-scale farmer, cultivates 1–3 ha manually with a hand hoe or cutlass (machete). Finally, about 5% of the maize area is planted by commercial producers, who usually cultivate 50 ha or more. These distinctions are important for targeting technology development and dissemination. For example, many small- and medium-scale farmers lack adequate labor and draft power to plant on time, so for these farmers the length of the maize growing season is effectively reduced.

The Role of Maize in Production and Consumption

Maize accounts for a little over 20% of domestic food production in Africa, a proportion that has increased over time as maize has replaced other food staples, particularly sorghum and millet. Production of wheat and especially rice has also tended to increase in relative importance over time. The importance of maize as a staple, however, varies widely across regions of Africa. In southern Africa, maize is by far the dominant staple, accounting for over 50% of the calories consumed and as much as 80% of the cultivated area in Malawi. Maize dominates the food economy of southern Africa, enjoying the same position as rice in southeastern and eastern Asia and wheat in western Asia. Per capita consumption of maize in several southern African countries (Malawi, Zimbabwe, Zambia, and Swaziland) averages more than 100 kg per year and is as high as 160 kg in Malawi. Only in Mexico and Guatemala—where maize probably originated—do people consume a similar amount of maize.

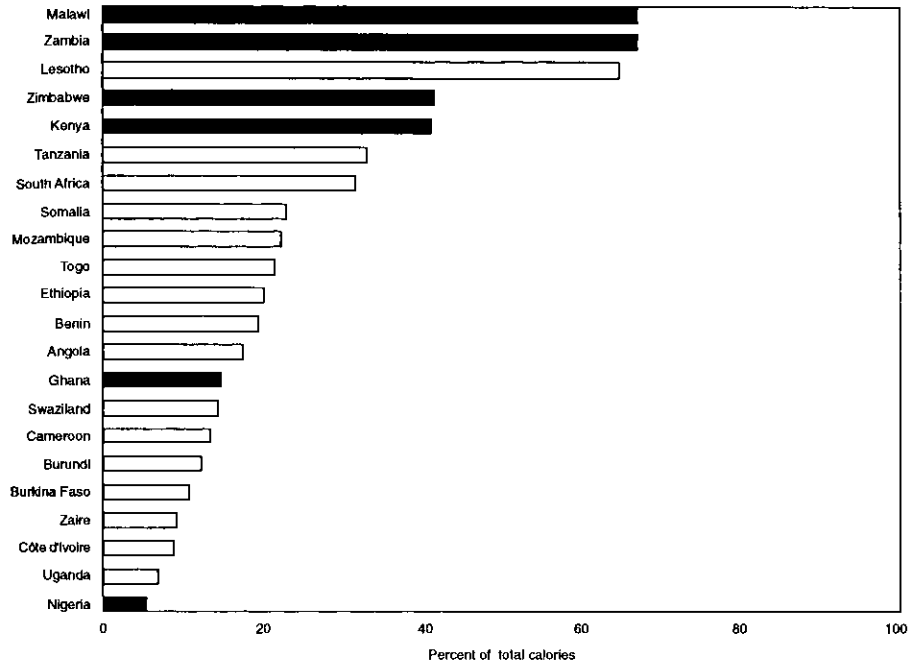
In eastern Africa, maize is the most important food staple, and its importance is growing with time. Maize accounts for about 30% of calorie consumption in the region, where Kenya is the leading maize consumer. Maize provides over 40% of calories in Kenya, and per capita consumption is 125 kg per year. In the interior countries of this region—Uganda, Rwanda, and Burundi—maize is a secondary staple in a diversified diet that includes plantains, potatoes, and other cereals.

In western and central Africa, maize is generally much less important in aggregate food consumption, averaging 23 kg per capita and only 13% of calories consumed. Here rice and wheat (together) provide the largest share of calories, followed by sorghum, millet, roots and tubers, and then maize. Maize, however, is the dominant food crop in some areas, especially parts of the coastal savanna and higher areas. Maize has also expanded rapidly as a commercial crop in the Derived and Guinea Savanna belt, where annual rainfall surpasses 750 mm. Much of this maize is destined for the market, especially the rapidly expanding urban population of the region.

The six country studies provide a cross-section of the overall importance of maize in Africa (Figure 2.4). In the four countries in eastern and southern Africa, maize accounts for more than 40% of calories. By contrast, in the two western African countries, maize provides 16% of food calories in Ghana and only 6% in Nigeria.

The demand for maize in the years to come will depend on many factors, including population growth, the relative price of maize, the effect of incomes and urbanization on consumption patterns, and the potential use of maize in livestock feed. At present, only about 5% of maize is used for animal feed; the major exception is South Africa, where half of all maize is fed to animals.

Figure 2.4 Africa, Selected Countries: Contribution of Maize to Total Calorie Consumption



Source: Computed from FAO data tapes.
Note: Countries with shaded bars are included in country case studies in part two of this book.

As incomes rise and urbanization increases, maize appears to maintain its place in consumers' diets. In general, consumers shift from sorghum and millet to rice and wheat, whereas the share of maize in the diet falls only slightly. Thus, given population growth and projected income growth, the demand for maize is likely to grow at 3.0–3.5% annually over the next 10 to 20 years (the higher figure allows for some growth in feed demand) (Rosegrant, Agcaoili, and Perez 1995). In other words, to meet future demand, maize production must increase at a faster rate than occurred during the past two decades.

Trends in Maize Production

Any analysis of trends in maize production in Africa has to be treated cautiously for a number of reasons. First, official statistics can be unreliable.[1] Second, because of the extreme variability of maize yields, estimates of

growth rates over time are sensitive to the choice of the time period of analysis. Because southern Africa experienced its worst drought of the century in 1992, the use of 1992 in the end period of analysis results in unrealistically low yields and yield trends. Third, official statistics show a sharp decline in production in countries affected by civil war. The estimates presented here attempt to take account of these various difficulties.

The years 1975–1995 were selected as the period of reference for analyzing production trends. During this period, maize production increased by 2.0% annually. This performance is not significantly better than that for other food staples and is less than growth in production of rice, the only crop whose per capita production increased. What is more important is how this maize production growth came about: More than two-thirds of the increase was achieved by expanding the area planted to maize. Yields of maize in Africa grew at only one-third of the rate achieved in other regions of the developing world. One reason for this difference is that much of Africa is at an earlier stage of land intensification, in which area rather than yield is the dominant source of production growth (Byerlee and Heisey 1996).[2]

The average yield of maize in Africa in the years 1989–1991 was 1.2 t/ha, which is double the maize yield estimated by Miracle (1966) for the 1950s, before improved technology became widely available. Yields were highest in eastern Africa, reflecting a favorable growing environment, as well as use of improved technology.

As noted earlier, yields have grown slowly. When countries that suffered prolonged civil war, such as Angola and Mozambique, are eliminated from the computations, overall yield growth is just under 0.5% annually. The use of improved maize seed and application of fertilizer to maize are not strongly correlated with yields. This absence of a clear relationship between maize yields and the use of modern inputs is an important puzzle that will be examined later in this book. In rain-fed areas of Asia and Latin America, where the use of green revolution–type technology is extensive, yield growth has averaged more than 2.5% annually (and has often been much higher) for two decades or longer.

In some cases, errors in statistics may explain apparent anomalies for specific countries. Some of the largest maize-producing countries in Africa, however, especially Zimbabwe, Malawi, and Kenya, have good systems for reporting agricultural statistics. Another factor may be the rapid shifts in the structure of maize production in some countries during the period of analysis. The proportion of maize produced by smallholders in Zimbabwe grew from less than 25% to exceed 70% in the late 1980s. A similar pattern has been observed in Zambia. These production patterns represent a shift to farmers who generally use fewer inputs and farmers who occupy less fertile land in more marginal rainfall environments. Growth in smallholders' maize yields in Zimbabwe averaged 1.5% annually

over the past two decades, a period when the national average maize yield grew at only 0.3% annually.

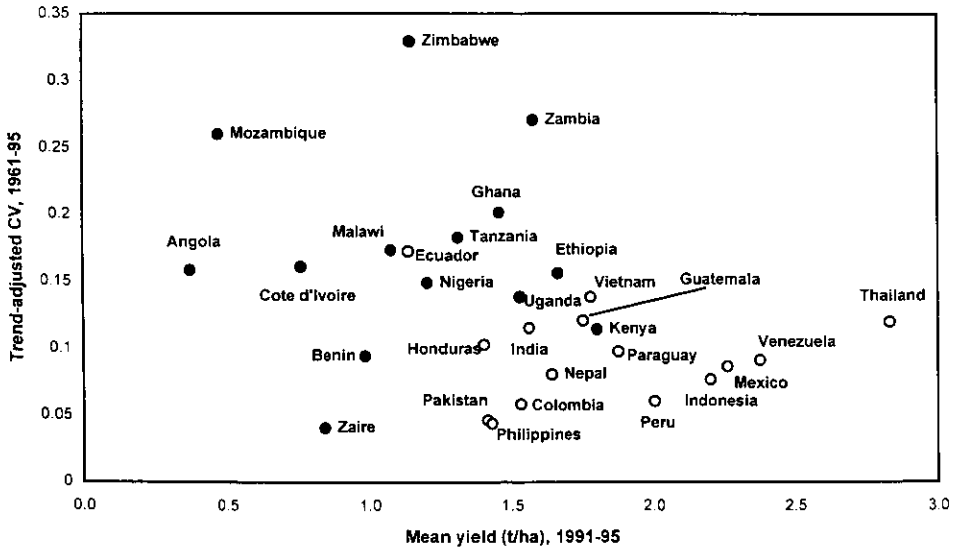
Another distinguishing characteristic of maize yields in Africa is their high variability. Figure 2.5 shows maize yield plotted against the adjusted coefficient of variation in maize yields for countries producing over 400,000 t of maize annually.[3] The degree to which African countries are grouped by *lower* absolute yields and *higher* yield variation is remarkable. Even among developing countries that have approximately the same maize yields, the variability of yields is nearly always higher in African countries. Climatic factors are responsible for much of this variability, but price variability may also play a role. Yield variability is most pronounced for the smallholder sector in Zimbabwe, where the coefficient of variation of yields exceeds 50%.

Evolution of Institutional and Policy Changes

Government Intervention in Maize Markets

Ever since maize started to become an important crop in Africa, colonial and independent governments have intervened heavily in the maize economy.

Figure 2.5 Developing Countries in Africa and Other Regions: Mean Yields and Yield Variability



Source: Computed from FAO data tapes.

Colonial governments promoted maize production, initially on the large-scale farms of settlers but later on African farms, during and after World War I. The construction of railways facilitated the movement of maize and its growing commercialization, especially for the expanding mining sector and international trade. As maize grew in importance, governments intervened more heavily to control production, prices, and imports. Maize marketing boards—endowed with the sole authority to purchase maize at prices fixed by the board, as well as to import or export maize—were established during the 1930s in most countries of southern Africa (e.g., Lukanty and Wood 1990), as well as in Tanzania and Kenya in eastern Africa. In western and central Africa, however, maize marketing has remained largely in the private sector and is subject to relatively little government regulation.

Intervention in maize marketing was usually accompanied by government control over input markets, especially following independence when governments and donors redoubled their efforts to modernize the smallholder sector. In most countries, seed was produced by the public sector through a government seed monopoly, and fertilizer was largely imported and distributed by the government. Prices of seed and fertilizer were often controlled and in many cases subsidized to promote adoption of these inputs. In Nigeria, for example, fertilizer subsidies were as high as 85% during the 1980s. Much of this fertilizer was directed to the rapidly expanding maize area.

The Era of Liberalization

With the advent of structural adjustment programs in the 1980s, the policy environment began to shift in many African countries. These programs aimed to remove policy distortions through exchange rate devaluation and liberalization, fiscal austerity, reductions in export taxes, liberalized trade, and reform of agricultural input and product markets. For Africa as a whole, real exchange rates were 20% lower in 1993 relative to 1987 (Donovan 1995). Seventeen countries liberalized food crop marketing. The status of liberalization with respect to maize markets was rather variable. Finally, 16 countries reduced or eliminated fertilizer subsidies and liberalized fertilizer marketing.

For several reasons, the effects of these policy reforms on agricultural growth rates have been less than anticipated. First, policy reform is still incomplete in most countries; in some cases, the process has been reversed. Second, the transition to private marketing has been slow and difficult, especially for markets for key inputs such as fertilizer. Finally, public-sector investments in rural infrastructure and agricultural research and extension have declined in some countries. An important issue is the extent to which policy reforms have affected incentives for food crop production.

We reviewed trends in real maize prices in eight countries and discovered no consistent correlation between policy reform and improved price incentives. Indeed, a country such as Ghana, which implemented reforms over a sustained period, had a sharply negative trend in maize producer and consumer prices. In addition, the withdrawal of government parastatals from food marketing has increased price uncertainty to producers in some countries, since the private sector has not always effectively filled the vacuum.

Conclusions

All indicators suggest that Africa's food production crisis deserves urgent action. The downward trend in per capita food production observed from 1971 to 1985 may have stabilized, but the low level of food consumption, high incidence of rural poverty, and rapidly increasing population all add to the urgency of the problem. Since maize is the most important food crop in Africa, improvements in the performance of maize production will be crucial to solving Africa's food security problems and alleviating poverty.

We predict that maize production will have to grow by about 3.0–3.5% annually to satisfy demand. This rate of growth substantially exceeds the 2.0% growth in production recorded over the past two decades. A rate of 3.5% cannot be achieved without expanding maize area, as well as intensifying production to increase yields. Fortunately, maize is produced largely in relatively favorable areas, some of which possess considerable potential for area expansion. At the same time, a large potential exists to increase yields in most maize-producing environments. Yields in all but a few areas are extremely low by world standards, whereas yield variability is very high in Africa relative to other regions. This means that a maize production strategy requires an increase in yields, as well as efforts to improve yield stability.

The performance of the maize subsector in any given country is the result of a complicated set of interactions over time among agroclimatic factors, historical circumstances, technological change, and the policy and institutional environment. This complexity limits the ability to devise broad policy prescriptions for Africa. The policy environment is now more favorable for agriculture in Africa than it was during the 1970s and 1980s. Price discrimination against the agricultural sector has been reduced in many countries, and liberalization of the markets is providing incentives for more private-sector participation. Many countries, however, continue to struggle with the transition to private-sector input and output marketing, and uncertainty in input supply and producer prices must still be addressed. These issues are analyzed in the following chapters.

Notes

1. For example, maize yields in Tanzania show a sharp discontinuity in 1976, apparently reflecting a revision of the statistical estimation procedure. Nigerian maize statistics also exhibit sharp discontinuities.

2. A closer examination of trends by decade and region within Africa indicates that maize area expanded most rapidly in western and central Africa, especially between 1985 and 1995 (Table 2.1). In that same decade, maize production expanded by 4.6% annually in western and central Africa, which also had the best yield performance. This situation reflects rapid growth in maize in Nigeria, Ghana, and other countries, especially in the savanna areas. In southern Africa, production has fallen over the past two decades, as both area and yields have stagnated or fallen.

3. The adjusted coefficient of variation is computed as $\sigma(1-R^2)^{0.5}/\mu$, where σ is the standard deviation, μ is the mean, and R^2 is the coefficient of determination of the trend regression line adjusted for degrees of freedom.