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Maize Revolutions in Sub-Saharan Africa

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Abstract

There have been numerous episodes of widespread adoption of improved seed and long-term achievements in the development of the maize seed industry in Sub-Saharan Africa. This summary takes a circumspect view of technical change in maize production. Adoption of improved seed has continued to rise gradually, now representing an estimated 44 percent of maize area in Eastern and Southern Africa (outside South Africa), and 60 percent of maize area in West and Central Africa. Use of fertilizer and restorative crop management practices remains relatively low and inefficient. An array of extension models has been tested and a combination of approaches will be needed to reach maize producers in heterogeneous agricultural environments. Yield growth overall has been 1 percent over the past half-century, although this figure masks the high variability in maize yields, as well as improvements in resistance to disease and abiotic pressures that would have caused yield decline in the absence of maize breeding progress. The authors argue that conducive policies are equally, if not more, important for maize productivity in the region than the development of new technology and techniques. Currently popular, voucher-based subsidies can "crowd out" the private sector and could be fiscally unsustainable.

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Maize Revolutions in Sub-Saharan Africa

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Introduction

Over the past three decades, economists have described maize research and development in Sub-Saharan Africa as an "emerging maize revolution" (Byerlee and Eicher 1997), a "stop-and-go revolution" (Howard 1997), a "delayed green revolution" (Smale 1995), an "obscured revolution" (Gilbert 1993), and a "failure" (Kydd 1989). Most often categorized as a qualified success (Eicher 1995), the maize productivity gains achieved through smallholder adoption of improved seed and fertilizer during the 1980s were driven in part by the appropriateness of the technologies themselves and in part by state policies that encouraged their use through supporting markets and prices. Although these policies successfully promoted maize production in many countries, they imposed massive costs on national treasuries and contributed to the fiscal crises that most African governments experienced during the 1980s and early 1990s (Jayne and Jones, 1997; Smith et al. 1997).

The structural adjustment programs that followed were designed to shift state involvement in markets from direct operations to public goods expenditures, bolstering private investments. In many cases, fledgling private sectors were unable to fill the void left by the withdrawal of the state and public investment has declined. Programs had a mixed record, and were often construed as imposed by the World Bank and IMF against the wishes of politicians and farm lobbies that had benefited from state marketing systems.

Policy experiments during the past 15 years since structural adjustment have ranged between two extremes. Consistent with the tenets of structural adjustment, governments such as those of Mozambique and Uganda have relied primarily on markets and regulated trade in order to coordinate food production and marketing. By contrast, governments in Malawi and Zambia have revived the "development state" concepts of the 1970s in order to promote national food security (Kydd 2009).

This paper updates Byerlee and Eicher's (1997) review of the performance of the maize supply chain in Sub-Saharan Africa. We take a circumspect view of maize technical change in the region. An immigrant crop, maize is today the most widely-grown staple food of Sub-Saharan Africa and an important wage good in many countries. Despite past successes, continued investment in maize productivity remains crucial to agricultural growth and food security. For example, investment in maize research is required to produce a new generation of improved varieties that are drought-tolerant, pest-resistant, and nutrient-efficient. In addition to appropriate seed, diversified maize farming systems and improved crop management practices will be essential for restoring soils in order to achieve productivity gains. To ensure adoption across the continent's heterogeneous production environments, farmers will need varied combinations of inputs and practices, diffused via pluralistic seed supply and advisory systems. Expanding markets in densely-populated areas with small-scale farms will require different approaches from areas with good potential, scattered populations and lower intensity of land use. Designing interventions to support market development will require persistent and careful monitoring of ongoing policy experiments.

Overview of Maize in Africa

Trends in Production[1]

Maize currently covers 25 M ha in Sub-Saharan Africa, largely in smallholder systems that produced 38 M in 2005-8, primarily for food. From 2005-8, maize represented an average of 27 percent of cereal area, 34 percent of cereal production and 8 percent of the value of all primary crop production (Table 1). This includes estimated area and production of green maize, which is highly valued as the harvest approaches at the end of the "hungry season". From 1961-2008, maize dropped slightly as a share of total area in primary crops, but not as a share of area of production of cereals, which has fluctuated between 32 and 45 percent over that time period.

The potential for expanding maize production in Sub-Saharan Africa is huge. Even after excluding protected and forested areas, an estimated 88 M ha of land that is not yet planted to maize is suited to the crop. Worldwide, this amount is equivalent to four times the area now planted to maize and over half of the additional land area that is suitable for maize (Deininger and Byerlee, 2011). By far the largest proportion of this area is found in Sudan. Other areas with considerable potential for expansion are in Eastern and Southern Africa, including Mozambique, Angola, Zambia, Madagascar and Tanzania.

However, maize producers in these regions are often far from population centers with the markets and financial services that are conducive to technical change. Physical access to markets is far more restricted for farmers in Sub-Saharan Africa than for farmers in other regions of the developing rural world. Only a quarter of farmers in Sub-Saharan Africa are within 2 hours of markets by motorized transport, as compared to nearly half of farmers in Asia and the Pacific, and 43% for the developing rural world. An estimated 75% of farmers are located more than 4 hours to the nearest market, by motorized transport, as compared to 45% in Asia and the Pacific (Kate Sebastian, pers. comm). Of course, most rural people in Sub-Saharan Africa have no access to motorized transport, so these figures understate the magnitude of the problem.

In sub-Saharan Africa, excluding South Africa, the highest growth in maize area, yields, and production from 1961 over the entire period has been in West Africa, and the least has been in Southern Africa where yields have stagnated at a little over 1 t/ha.[2] These differences are

[1] For consistency, despite well-known limitations, all figures reported in this section are calculated from FAOSTAT data available at http://faostat.fao.org. Regional names are those used by FAO, although countries included by region differ. Country lists are compared in Annex 1.

[2] An additional 2.8 million ha is grown in South Africa, mostly on large-scale commercial farms (averaging about 380 ha each), much of it yellow maize for animal feed. Owing to its apartheid legacy, smallholder maize contributes less than 15% of national production, and accounts for only a minor fraction of household income of black rural families. Maize marketing and pricing policy issues focus primarily on keeping food prices at tolerable levels for urban consumers, and ensuring the continued viability of the large commercial farm sector, with very little attention to smallholder maize production or marketing. National yields have steadily improved to reach about 5 t/ha while area has declined. Except in drought years, South Africa produces a modest maize surplus for export. Yield increases partly reflect deregulation of the industry and the reduction of maize area where it is no longer competitive because of lower yields and higher risks. Commercial farmers have also invested substantially to improve maize production. About one quarter of the area is irrigated. In Northern Cape Province, where all maize is irrigated, yields are around 10 t/ha. Farmers also use advanced maize hybrids, including genetically modified seed, and apply about 75 kg/ha of fertilizer nutrients, much higher than elsewhere in Africa. Given its uniqueness, we have chosen not to include South Africa in analysis of regional data.

reflected in regional average yields, which are as high as 1.7 in West Africa and 1.5 in East Africa, but only 1.1 in Southern Africa. From 1961-2008, area growth accounted for two-thirds of the overall 3 percent annual production growth in Sub-Saharan Africa; yield growth has averaged only 1 percent annually.

Growth rates vary considerably in each region of the continent and by decade (depending on endpoints chosen and the incidence of droughts), sometimes appearing negative but also much higher during episodes of success. In some cases, such as Zimbabwe and Zambia, trends in maize production have changed abruptly with policy shifts, and in other countries such as Angola and Mozambique, prolonged civil wars depress trends. The yield gap between countries in Sub-Saharan Africa and those with comparable production conditions is large, although it narrows if only rainfed areas are considered. It is important to recognize, however, that yield variability is much greater in Sub-Saharan Africa than elsewhere on a world scale (Box 1).

Box 1: How do yields in Sub-Saharan Africa compare to those of other tropical regions?

Average yields and yield growth rates in other countries in tropical rainfed environments provide points of contrast. From 2005-2008, average maize yields were estimated at 3.8 t/ha in Brazil, 3.1 t/ha in Mexico, 2.5 t/ha in the Philippines, and 3.9 t/ha in Thailand, compared to 1.4 t/ha in Sub-Saharan Africa. Annual yield growth from 1961-2008 averaged 2.4 percent, 1.8 percent, 2.8 percent and 1.6 percent respectively in Brazil, India, Philippines and Thailand, on average about double the 1 percent growth in Sub-Saharan Africa. However, a careful analysis of sub-national data, suggests that netting out irrigated area which is important in all but Brazil, the gap between yields in Africa and rainfed areas elsewhere is smaller although still sizeable. For example, rainfed maize yields in Mexico are just over 2 t/ha and have been rising at about 1.9 percent per annum since the 1970s. Much of this yield gap would be due to higher and more widely adopted fertilizer use on Mexican maize.

Maize yield variability is extremely high in sub-Saharan Africa. Even among developing countries that have approximately the same mean yields, the variability of yields is nearly always higher in countries of Sub-Saharan Africa (Byerlee and Heisey 1997). Countries in Southern Africa have the highest coefficients of variation (Table 2). Zimbabwe's coefficient of variation in maize production from 1991-2007 was 41 percent, as compared to 33 percent in Malawi, 31 percent in Zambia, and only 11 percent in Kenya. Climatic factors are responsible for much of yield variability, which as discussed later also aggravates price variability. By contrast, in countries where rice is major food staple in Asia, coefficients of variation in production are in the single digits.

Trends in Maize Consumption and Trade

In high-income countries, an estimated 70 percent of maize is destined for feed, only 3 percent is consumed directly by humans, and the remainder is used for biofuels, industrial products and seed. In Sub-Saharan Africa outside of South Africa, 77 percent of maize is used as food and only 12 percent serves as feed.

Maize, predominantly white, is consumed in Sub-Saharan Africa boiled or cooked. The two types of white maize (dent and flint) are largely associated with different food products (FAO, 1997). Dent maize is soft and floury and used for porridges, while flint maize has a hard, vitreous endosperm and is used primarily for gruel or couscous. In parts of Sub-Saharan Africa such as Malawi, flint maize has been preferred to dent because of smaller losses incurred in traditional storage and processing practices.

Maize has accounted for 22 to 25 percent of starchy staple consumption in Africa from 1980, representing the largest single source of calories, followed closely by cassava.[3] The

[3] By region, no trend is apparent in per capita maize consumption over the past five decades, although a slight increase is visible in Central Africa. However, in Ethiopia, maize as a percentage of daily energy has nearly doubled from 10 percent in 1961-63 to 19 percent in 2003-2005

significance of maize as a staple varies across the continent. The highest amounts of maize consumed are found in Southern Africa at 85 kg/capita/year as compared to 27 in East Africa and 25 in West and Central Africa. In Lesotho, Malawi, South Africa, Zambia and Zimbabwe, average consumption is over 100 kg/capita/year. These amounts represent more than 50 percent of total calories in Lesotho, Malawi and Zambia, 43 percent in Zimbabwe, and 31 percent in South Africa.

As a point of comparison, the 2007 average of rice consumption in Southeast Asia as a whole is 131 kg/capita/year and rice represents 55 percent of total calories. Thus, for some countries in Sub-Saharan Africa, maize is important enough in farm production, incomes and diets that yield gains could have impacts on producer and consumer welfare similar to those that occurred with improved rice in Southeast Asia. However, food staples are much more diversified in many areas of Sub-Saharan Africa than they are in Asia (Larson et al., 2010).

Urbanization and Trade

Net maize imports to Sub-Saharan Africa average around 1.5 M t or less than 5 percent of total consumption. Maize imports are generally small in West and Central Africa, but play an important role in Eastern and Southern Africa. Trade within the region, both formal and informal, is also significant in some years. However, many countries resort to discretionary and unpredictable trade policy controls such as import and export bans, as well as direct state trading operations, which have curtailed the potential of regional trade to reduce price instability (Chapoto and Jayne 2009).

Few countries in Sub-Saharan Africa are competitive in global markets for exports, largely because of high transport and logistics costs; for the same reasons, most countries are competitive for import substitution. Given both greater productivity and improved infrastructure, the expansion of regional markets could eventually provide the basis for competition in export markets (World Bank, 2009).

Within the next few decades, the majority of Sub-Saharan Africa’s people will be living in urban centers and will depend on a diminishing minority of the population to produce food. Ongoing demographic change means that countries in eastern and southern Africa regions are increasingly dependent on imports of staple foods. Net maize exports in East and Southern Africa as regions display downward trends, with substantial variability, over the past few decades (FAOSTAT). Net exports are negligible in West and Central Africa and show no trend. All countries in Southern Africa have a negative trend in net maize exports. In East Africa, there is a negative trend in net maize exports for 2 of 6 countries (Kenya and Rwanda). Kenya and Zimbabwe, net exporters of maize in the 1970s and 1980s, are now chronic importers. Malawi has also been a net maize importer in four of the past six years. The reduction of maize production subsidies in South Africa has also reduced the exportable surplus in that country, although it remains a reliable exporter.

Urban populations are growing at over 4 percent per year in Sub-Saharan Africa compared to less than 1 percent among rural populations. To feed urban populations, especially in coastal cities, maize imports would have been much larger but for rising imports of wheat and rice. For example, in the urban areas of East and southern Africa shown in Table 3, wheat and rice (much of which is imported) are more important than maize in consumption. The consumption shares of wheat and rice in urban areas are growing rapidly even in areas where maize has long been the primary staple crop, reflecting the overall decline in maize selfsufficiency in these countries as well as a shift in urban preferences toward "convenience staples" such as bread and rice (Jayne et al., 2010).

Technical Change

Special Challenges of Maize R&D

Morris (1998) provides an in-depth characterization of maize that distinguishes it from rice or wheat, the world's two other major cereals. Because maize is a cross-pollinating crop, a field of maize that is harvested and replanted will result in maize plants that differ from the preceding generation and from each other. Improved, open-pollinated varieties quickly lose their identity unless seed is frequently replaced. At the same time, cross-pollination enables breeders to exploit "hybrid vigor." The most rapid genetic improvements in cereals have been realized with hybrids in temperate maize (Fischer et al., 2009). Provided that farmers replace the seed each season, yield advantages of hybrids can be substantial. Whether farmers grow improved open-pollinated varieties (OPVs) or hybrids, however, they are reliant on a commercial seed industry to a much greater extent than growers of improved rice or wheat.

Maize is also more photosensitive, yet is grown over a wider range of altitudes and latitudes than any other food crop, under temperatures ranging from cool to very hot, on wet to semi-arid lands, and in many different types of soil. Environmental heterogeneity leads to continual interaction of genotype with environment and the formation of new maize types in farmers' fields through natural outcrossing and farmer selection. Well-adapted germplasm is highly specific to location. Thus, noteworthy advances in temperate maize among industrialized countries cannot be transferred to tropical environments of developing countries, and progress achieved in one tropical environment cannot be easily replicated in another. The preferences of Sub-Saharan Africans for white maize have also constrained progress in breeding.

Heisey and Edmeades (1999) report that compared to wheat and rice, maize is more likely to be grown in areas that are regarded as "marginal" from a physical or economic standpoint. They argue that crop management interventions may have greater potential for significant impact on maize production in these environments than genetic solutions, though they may be costlier to develop and diffuse across the continent's heterogeneous landscapes and may ultimately reach fewer farmers than stress-tolerant germplasm.

Development of Maize R&D Systems

Episodes of successful maize breeding and adoption in Eastern and Southern Africa have been reviewed in detail by Smale and Jayne (2003) and Lynam (2010). The products of early scientific efforts, initiated on the eve of independence in Kenya (1963), Zambia (1964) and Malawi (1964), and several decades before the independence of Zimbabwe (1980), were promising. These served as the basis for generations of new maize hybrids and other improved varieties that spread rapidly among smallholders in newly formed African states.

Just after independence in 1963, Kenya's research program in Kitale, located in the part of the highlands populated by European settlers, released a varietal hybrid (Hybrid 611) that was a cross between an improved, open-pollinated maize variety developed from local stock and landrace stock from the Americas (Ecuador 573). H611 diffused among large- and small-scale farmers in the high-potential areas of Kenya as rapidly as the hybrids that swept across the U.S.

Corn Belt in the 1930s and 40s (Gerhart 1975). H611 has since served as the basis of many of the hybrids released by the national maize program (Hassan et al. 1998).

Similarly in Zimbabwe, just after independence in 1980, smallholder Africans rapidly adopted the R-200 series of maize hybrids. Originally bred for European settlers, they were suitable for cultivation on sandy soils in low-rainfall areas and performed relatively well for smallholders (Rohrbach 1988). Following independence in 1964, Zambia's maize breeders also introduced an impressive array of both hybrids and improved open-pollinated varieties (Howard 1994).

The lack of a large farm sector prior to independence and local consumption preferences delayed Malawi's maize revolution. Malawi's smallholder farmers preferred flint maize types that processed and stored well on their farms. At that time, regional breeding efforts were focused on dent maize types suited to large-scale milling, and flint breeding materials from outside Malawi were not easy to find. Malawi's breakthrough hybrids (MH17 and MH18), not accomplished until 1990, resulted from an innovative top-cross of Malawian lines, including SR-52, with flint maize populations. The earlier-maturing of the two, MH18 often escaped dry spells, processed and stored well on-farm, and yielded more than local maize even when both were unfertilized (Heisey and Smale, 1995). According to surveys undertaken by the National Statistical Office in 2006, MH17 and MH18 were still planted to over half of the area of improved maize in this densely-populated, maize-dependent nation (Sauer and Tchale, 2009).

The International Maize and Wheat Improvement Center (CIMMYT) played a key role in the development of the successful hybrids in Malawi. Although CIMMYT had a regional presence in maize breeding from the late 1970s, it only seriously invested from 1985 when it established a research station at Harare in Zimbabwe. It has since maintained a strong presence in the region and many of the more recently released hybrids and OPVs contain CIMMYT parentage.

In West Africa, where there were no settler farmers like those found in Eastern and Southern Africa, maize hybrids were not developed. The scientific breakthrough in West Africa came with the release of the open pollinated varieties, TZB and TZPB, developed by IITA during the 1970s. These varieties combined high yields with resistance to rust and blight (TZPB) and drought tolerance (TZB), spearheading the Nigerian maize revolution in the 1980s (Smith et al., 1997). They have been also widely adopted elsewhere in West Africa. Later varieties focused on streak virus resistance and are the basis for currently grown varieties (Alene et al., 2009). Overall, the number of varieties released in the region jumped from less than one annually in the 1970s to five in the 1980s, to 12 in the late 1990s.

Strong national programs are critical to successful R&D systems. Investment in national R&D programs increased rapidly from the 1970s but then stagnated in the 1990s. Spending on R&D fell in about half of the countries of Sub-Saharan Africa during the 1990s (Beintema and Stads, 2007). Over the whole period staffing increased faster than funding, so that funding per scientist fell to less than half of the levels of 1971. Research capacity has also been affected by staffing discontinuities in the national maize breeding programs, and shifting emphasis between efforts to breed hybrids as compared to improved, open-pollinated varieties. Two of the three maize breeding programs recently reviewed by Lynam et al. (2010), in Ghana and Malawi, have lost all the senior maize breeders that were instrumental in earlier successful maize varietal releases. Lynam et al. (2010) identified only Kenya, with six maize breeding programs and six

PhDs in maize breeding, as having substantial capacity in maize breeding. The share of maize in the national research budget is as high as12 percent in Kenya, which is similar to the share of rice in Asian research systems (Beintema and Stads, 2007).

Investments in the crop improvement programs at international research centers also declined during the 1990s. IITA's budget for maize research fell from $10 m in 1988 to $5 m in 2000 (Alene et al., 2009). However, re-investment in center breeding programs by the Bill and Melinda Gates Foundation and growing emphasis on regional breeding programs has in part substituted for the centralized breeding programs of the International Agricultural Research Centers (Lynam et al., 2010).

Despite the fluctuating fortunes of maize breeding programs, research impacts in the region have been demonstrated by Manyong et al. (2003), Alene et al. (2009) and Morris et al. (2003). For example, Alene et al. (2009) estimated rates of return to research exceeding 40 percent in West Africa from 1971 to 2005.

Partly offsetting weaknesses in public research systems has been a sharp rise in private sector interest in plant breeding and the seed sector. In a review of varietal releases in 13 countries (excluding South Africa), Setimela et al. (2009) found that 250 varieties and hybrids had been released during the period, 2002-06 (or nearly four per country per year). Over 60 percent were private hybrids. Most activity was evident in Kenya, Malawi, Zambia and Zimbabwe. Many of these hybrids were probably based on inbreds produced by CIMMYT, IITA or national public sector maize programs.

Adoption of Improved Maize

The most recent estimates place the adoption of improved open-pollinated varieties and hybrids at 44 percent of maize area in Eastern and Southern Africa in 2006-07 excluding South Africa, and 60 percent in West and Central Africa in 2005 (Tables 4 and 5). These data suggest a substantial increase in adoption over the past decade, primarily in West and Central Africa. Morris et al. (2003) estimated that in the late 1990s, excluding South Africa, only 36 percent of maize area was planted to modern maize (mostly hybrids). Manyong et al. (2003) estimated that 37 percent of maize area in West and Central Africa was planted to modern maize in the late 1990s (mostly to improved open-pollinated varieties).

However, adoption figures for individual countries in Eastern and Southern Africa are erratic, depending in part on the estimation method. Data assembled from a range of sources indicate that adoption was as high in 1990 as it is now in that region, dipping in the mid-1990s (Table 4). Adoption of modern maize in Kenya appears to have leveled at 70-75 percent of maize area. In Zimbabwe, adoption rates reached 96 percent as early as 1990 (Lopez-Pereira and Morris 1994).

Slow turnover of maize hybrids on farms may explain stagnating yields in Eastern and Southern Africa. For example, in 1996-1998, the estimated average age of varieties grown in Ethiopia was 14 years and one variety 20 years old constituted a third of maize seed sales (CIMMYT pers. comm,). In 1992, the average age of all maize varieties and hybrids grown by farmers in Kenya was 14.5 years (Hassan 1998). H614D, derived from H164 released in 1986, was planted on 42 percent of maize area in 1992 and continued to occupy 51 percent of maize area in 1998 and 48 percent in 2010 (Hassan 1998; F. M. Ndambuki, Kenya Seed Company, pers.comm, May 11). Outside of the high-potential areas where H614 has superior adaptation, new adoption patterns are indeed emerging, but the range of hybrids on farms in Kenya still does not reflect the large number now registered for sale.

Despite a later start, adoption of improved maize is now higher in West and Central Africa. A mere 4 percent of maize area in West and Central Africa was planted to improved maize varieties in 1981 (Alene et al. 2009). West Africa appears to have also experienced a more robust rise in the adoption of improved varieties since 1990, although it is especially difficult to reliably estimate areas under improved open-pollinated varieties[4]. Ghana and Nigeria were the prominent success stories of the 1980s. Impressive rates of adoption also occurred in Mali, where maize is grown in cotton-based systems, although the area is relatively small.

Despite abundant evidence of dynamic change, the data reported in Tables 4 and 5 indicate that roughly half of Sub-Saharan Africa's maize area continues to be planted to farmers' varieties, though through cross-pollination and farmer selection, breeders often suggest that many of these have been influenced by proximity to improved maize.

Fertilizer Use

As shown above, even in countries where improved maize covers much of maize area, only modest yield gains seem to have been achieved. Although the use of improved maize can be a catalyst for increasing farmers' use of other inputs, and especially fertilizer, such broad-based change has only occurred in some parts of Sub-Saharan Africa. Most farmers do not adopt the additional production practices needed to sustain yield improvement. This is particularly noticeable with respect to practices for maintaining and enhancing soil fertility, even though the shortening of the bush fallow rotation as a consequence of population pressure has made poor soil fertility the major constraint to raising productivity in many areas.

For all of Sub-Saharan Africa, about 40 percent of fertilizer is used on maize, implying that the average dose is only about 17 kg/ha of nutrients compared to the developing country average of 100 and the industrialized country average of 270 kg/ha on the same crop (Morris et al. 2007; Heisey and Norton 2007). While it is incorrect to surmise that modern maize "depends" on fertilizer, modern maize does generally trace a steeper response curve for fertilizer than do traditional farmers' varieties. Maize is a heavy consumer of fertilizer, leading fertilizer demand in industrialized countries among major cereals, and the second most heavily fertilized crop on a global scale, after potatoes (Heisey and Norton 2007).

Farmers grow improved varieties without fertilizer in many areas of Africa, especially in marginal areas, such as the drier zones of Kenya and Zimbabwe, but also some relatively favored areas, such as Ghana. Higher adoption rates for improved seed than fertilizer reflect the high costs of fertilizer in Africa, lack of input availability, and farmers' cash constraints.

Even where fertilizer is used, it is often used inefficiently. A single recommendation is provided for wide areas, which does not account for the diversity of smallholder situations and the acute cash constraints under which they operate. Mistaien's (2001) analysis, which employs a benchmark productivity measure computed by matching farm household survey data to optimal

[4] Because of the difficulty in measuring areas planted to improved OPVs, in particular, estimates should be considered with caution. Almost all of the maize area in West African countries, with the exception of Nigeria, is planted to improved open-pollinated varieties. Given that the private seed system has not been active, it is likely that farmers practice seed saving for much more than the recommended number of years and because of cross-pollination, it may be difficult to differentiate improved from unimproved materials.

fertilizer response functions for maize based on agronomic field experiments in Kenya, indicates that achieving technical efficiency could improve average yields by about 60 percent.

Low agronomic efficiency results from poor soil and moisture conditions, which can be remedied by adding organic sources of nitrogen. Fertilizers cannot profitably increase crop yields if soils are severely degraded. Recent research in Kenya has confirmed that removing fertilizer supply constraints will encourage use by wealthier farmers who cultivate better soils but have no impact on use by poorer farmers who grow maize on degraded land where fertilizer response is not enough to make its use profitable (Marenya and Barrett 2009a,b). Survey data commonly indicate that the contribution of fertilizer to food grain yields varies tremendously across farms even within the same villages. Households in Xu et al.'s (2009) Zambia study are characterized by a great variation in the marginal productivity of nitrogen, even in the same agro-ecological and soil conditions, which most likely reflects differences in farmers' management ability, knowledge about appropriate application rates, and whether they are able to acquire fertilizer in a timely manner. Simply bringing fertilizer response rates among farmers in the bottom half of the distribution up to the mean would contribute substantially to household and national food security (Nyoro et al., 2004).

Experts recommend greater emphasis on integrating organic matter, such as manure from livestock or post-harvest crop waste, to raise soil carbon levels and make nutrients from fertilizers more available to plants. In Malawi, Sauer and Tchale (2009) found that controlling for other factors, maize yield response to fertilizer was higher with integrated soil fertility management. Similarly, a decade of experimentation in Malawi by Snapp et al. (2010) provides evidence that integration of semi-perennial legumes (such as pigeon pea, which produces grain) can provide a foundation for sustainable crop management. Modest application of nitrogenous fertilizer to monoculture maize was effective at doubling yield, but a rotation system with semi-perennial legumes reduced the variability of yields, produced grain with 45 to 70 percent higher protein, and improved nitrogen recycling. Across sites, profitability and farmer preferences, expressed by spontaneous adoption, were in accord with these findings.

Other Crop Management Practices[5]

Extension efforts increasingly emphasize the use of more legumes, intercropping, organic manure, reduced tillage, herbicides and agroforestry, and there are some indications that farmers are adopting such practices (Holden and Lunduka 2010a). Intercropping may also be rising in some maize-based systems. Based on panel data collected by Tegemeo Institute of Egerton University, Ariga and Jayne (2010) found a rising trend in the proportion of maize area planted in more complex intercropped patterns from the mid 1990s.

Experience from many African countries has shown that seasonal labor availability is an important constraint on the acceptance of improved management practices such as plant spacing and weeding that are relatively labor intensive. If these are recommended as a package with fertilizer and seed, the profitability of other components is also affected. Even where land is in short supply, seasonal labor shortages often decisively influence farmers' choice of technology for several reasons: hand-hoe agriculture demands a great deal of labor, off-farm work is

[5] Technologies and management practices to reduce post harvest losses should be added to the list of opportunities for improving the efficiency of the maize supply chain. Various estimates put post harvest losses for maize grown by smallholders in the humid tropics of Africa at 15-20%.

important in many areas, and a pool of landless rural laborers is not available when demand for labor is greatest (Low 1988). It is therefore critical to evaluate recommended management practices in terms of their effect on the returns to labor.

Reflecting this labor constraint, farmers in the savanna of western Africa and much of southern Africa and Ethiopia have adopted animal traction in maize-based systems. However, a seasonal draft power constraint often emerges because animals are in short supply or in poor condition during the peak demands for land preparation (Collinson 1982). This has led to efforts to develop conservation tillage practices that eliminate tillage, retain crop residues and integrate legumes. While early experience has sometimes been positive (e.g., in Zambia, Haggblade et al., 2010), adoption is still limited and considerable research is needed to adapt conservation agriculture practices to locally-specific biophysical and socioeconomic conditions (Giller et al., 2009).

There is little doubt that research on crop and resource management to overcome seasonal labor constraints, and maximize returns to cash inputs, while conserving the soil base and enhancing soil fertility over the longer run, will go a long way toward increasing productivity and sustainability of maize-based systems. Research on these constraints has increased sharply in the past decade, but success, measured in terms of adoption, has not been impressive. Practices must be adapted to locally-specific situations in order to account for agroclimatic circumstances, population pressure, labor availability, and the stage of infrastructural and institutional development. Special efforts are also needed to transfer and adapt them once developed, given that many are knowledge-intensive, highlighting the importance of extension.

Agricultural Extension

Without doubt, maize farmers have been major beneficiaries of the expansion of national extension systems. Extension was a driving force behind the diffusion of improved maize technology to smallholders in all the countries that have experienced wide uptake of improved maize technologies (Kenya, Nigeria, Ghana, Zimbabwe, Zambia, Mali). Despite these successes, management problems arose as the number of extension staff increased and operating budgets for travel and farm visits decreased due to fiscal constraints. In Kenya, De Groote et al. (2006) found a striking decline in access to extension services from 58 percent of maize growers in 1992 to only 30 percent in 2002, even as access to credit grew from 8 to 26 percent.

General disenchantment with extension has led to many efforts to ‘fix’ public extension. One of the most influential of such efforts was the training and visit (T&V) model of organizing extension, supported by the World Bank from 1975 to 1995 in 27 countries of Africa. The T&V approach aimed to improve performance of extension systems by strengthening their management and formulating specific and regular extension messages (Anderson et al., 2006). T&V projects helped extension agencies reach greater numbers of farmers and sometimes spearheaded rapid adoption of maize technologies (Cleaver 1993; Balcet and Candler, 1981). However, where rigorous evaluations of impacts of T&V extension on productivity have been conducted as in Kenya, the results were disappointing (Gautam, 2002). In addition, the T&V system exacerbated fiscal sustainability and lacked real accountability to farmers (Anderson, et al, 2006). By the early 1990s, a World Bank evaluation found that at least half of the extension projects in Africa were rated as “unsatisfactory” due to the use of a top down rigid model with insufficient attention to heterogeneous production conditions and circumstances of farmers in rainfed areas (World Bank 1994).

Another approach was initiated by Sasakawa-Global 2000 (SG2000), an NGO, to demonstrate available yield-enhancing technology to farmers and policy makers in Ghana in 1986. SG 2000 has assisted public extension workers to conduct thousands of large (0.5 ha) demonstrations on farmers' fields to show the potential of a new technological package of seed and fertilizer in 14 countries in Sub-Saharan Africa (http://www.saa-tokyo.org/english/country/). Maize has been by far the major crop included in the SG2000 programs.

The SG 2000 project in Ghana claimed the most success. The extensive coverage of on-farm demonstrations was undoubtedly a major factor in the wide adoption by Ghanaian farmers of maize seed-fertilizer technology. An even larger program in Ethiopia, initiated in the early 1990s under the Participatory Demonstration and Training Extension System, integrated extension with provision of seed, fertilizer and credit. Once scaled up, the program reached about 40 percent of the roughly 10 million farm households in Ethiopia over a 10-year period (3.6 million demonstrations in 1999 alone) and demonstrated that the adoption of seed–fertilizer technologies could more than double maize yields. Despite these efforts, adoption of maize technologies in Ethiopia is still low and a viable private sector input distribution system has yet to emerge (Spielman et al., 2010).

The SG 2000 country projects have demonstrated that maize yields can reach 4-5 t/ha from average national yields of 1-1.5 t/ha, serving as a reminder that rapid adoption of new technologies is possible in medium-to high potential areas when relevant technology is combined with input delivery systems and market opportunities. When programs withdrew, the realities of overcoming input supply discontinuities, extending supply chains into remote rural areas, and forging solvent local agro-enterprises persisted.

Since the 1990s, a spectrum of other extension innovations have been introduced in Sub-Saharan Africa, with many systems moving to pluralistic approaches with different models often being used within a country (Davis 2008). Extension is still largely publicly funded, but funds often flow through local governments, NGOs and farmer organizations that have a controlling interest in fund allocation. To provide more accountability, many governments moved away from centralized systems and transferred to local governments the responsibility for delivering extension and, in some cases, financing it, in line with wider efforts to decentralize government closer to its local constituents. Although these are good reasons to decentralize extension, various challenges, including political capture by local elites, have often compromised progress in delivering more effective advisory services.

Uganda's National Agricultural Advisory Services empowered farmer organizations by providing them matching grants to contract NGOs and private providers to deliver specific advisory services. This program significantly increased gross farm revenues from 2004 to 2007 but impacts have differed by region, and have been greater for high-value enterprises and male farmers, but also for poor farmers (Benin et al., 2010).

One extension model is the Farmer Field School, originally designed as a way to introduce integrated pest management in Asia. The schools have been introduced, mostly on a pilot basis, in several African countries, and their scope has been broadened to other practices and technologies (van den Berg and Jiggins, 2007). Evidence of impacts, although still limited, suggests that the approach can significantly enhance farmers' knowledge of new options. In the pilot districts where the approach has been used in Kenya, Tanzania and Uganda, incomes rose by some 61 percent on average, and women farmers and farmers without formal schooling gained most (Davis et al. 2010). Critical reviews of the evidence, most related to use of integrated pest management, suggest that Farmer Field Schools have not generated changes beyond local communities (Davis 2006), tending to favor more privileged farmers within those communities (Tripp, Wijeratne and Piyadasa 2005). Tripp, Wijeratne and Piyadasa, as well as van den Berg and Jiggins 2007) express concern that the assessment of FFS has been narrow, potentially biased, and focused on the short-term. In an econometric analysis based on comparison of changes between control and treatment groups, Feder, Murgai and Quizon found that the training had no statistically significant impact on the yields or the pesticide use among the participants or others in the same communities, raising questions concerning the high costs per participant and the financial sustainability of the approach.

Evaluation of extension experiments is limited to date (Anderson and Feder 2004). Still, a range of options are now available for improving the performance of extension systems. The challenge now is to scale up successful innovations and close out ineffective systems.

Emerging Policy Environments

The experience of maize technical change in Sub-Saharan Africa underscores the role of policy as a determinant of development, adoption and impact. This section discusses recent policy experience with respect for seed, fertilizer, input subsidies, and maize markets, highlighting Ethiopia, Kenya, Malawi, and Zambia. The case of Ethiopia represents strong state intervention in input markets (a seed-fertilizer "technology push") with a liberalized grain market. Kenya's government has retained some control over maize grain markets, but has largely liberalized fertilizer markets and to some extent seed markets. Zambia's and Malawi's governments exert strong control over both input and maize grain markets.

Seed Policies

The burgeoning demand for maize grain in Sub-Saharan Africa would suggest a healthy farmer demand for certified seed, but even though maize seed markets may be better developed than are markets for most other crops, the practice of farmer seed-saving remains common. For example, although hybrids have been widely adopted in Zambia, survey data suggest that during the 2007/8 maize growing season, 59 percent of maize growers use non-traded or recycled seed (also see Chapter 9 for Kenya and Uganda).

The central role of the seed industry has been repeatedly emphasized in policy analyses of Eastern and Southern Africa, and much progress has been made in developing the private seed sector in this region based on hybrid seed. In 2009, seed companies, including a few public companies, accounted for 98 percent of the market. More than half were private national companies, and about one fifth each were multinational and regional private companies (Langyintuo et al., 2009).[6] Langyintuo et al. (2009) concluded that the major bottlenecks in the seed industry of Eastern and Southern Africa were lack of awareness of the availability and value

[6] Nongovernmental organizations and national research organizations accounted for a scant 4 percent of all seed marketed in the region.

of existing varieties, the high investment costs to set up seed companies, outdated and rigid seed policies, and lack of credit and skilled human resources. Seed policies known to impede the development of the seed supply chain include lengthy variety release and seed certification requirements, which delay product lead times, and import-export restrictions on seed, and taxation policies. In Kenya, with its elaborate regulatory framework, new varieties take the longest to reach farmers' fields. Efforts to harmonize seed laws and regulations within the region have been underway for many years in both Eastern and Southern Africa, and in West Africa in order to speed varietal release across the region by allowing approval of a variety throughout a region once one country has approved it. However, implementation progress has been very slow.

In Kenya, despite liberalization and the entry of numerous new seed companies, Kenya Seed Company (KSC), the parastatal organization, still accounted for 86 percent of maize seed sales in 2004, reflecting its exclusive access to hybrids produced by KARI. Nonetheless, the distances traveled by farmers to the nearest hybrid seed retailer shortened between 1997 and 2007 (Ariga and Jayne 2010). According to Ariga and Jayne, greater progress has been made in the lowland and mid-altitude zones, with the release of improved varieties by KARI and by private seed companies. De Groote et al. (2006) report rising use of improved maize seed in the lowlands, reflecting the efforts of KARI to develop new varieties, and particularly hybrids, for that zone.

In contrast to the case of Kenya, Ethiopia's seed system remains state-based and top down, integrating extension, seed, fertilizer and credit into fixed packages. Improved seed production and multiplication is carried out by the Ethiopian Seed Enterprise (ESE), a fully state-owned company that is the only formal source of seed for most crops. After the market reforms of the 1990s, seed production and distribution was opened to the private sector, but by 2004, there were only eight active firms, most of them involved in hybrid maize seed as subcontractors to ESE. In 2004, approximately 70 percent of maize seed, mostly hybrid, was still produced by ESE (Alemu et al. 2007). An even smaller level of private sector activity is seen in the distribution and retail side of the market—Pioneer Hybrid is the next largest player in the industry, producing 16 percent of the seed, but relying on the public sector to distribute about half of it to farmers. Not surprisingly, purchased seed in 2007-8 accounted for just 20 percent of the area under maize cultivation.

Fertilizer Policies

Both supply and demand constraints have hindered the emergence of viable fertilizer markets in Sub-Saharan Africa (Heisey and Norton, 2007; Morris et al. 2007). Since nearly all fertilizer is imported, the cost of fertilizer is dependent on transport costs, and landlocked countries are particularly disadvantaged with respect to this bulky input. Transport and logistics costs in African have been found to be three to four times higher than they are in the US, explaining the fact that in general farmers in Sub-Saharan Africa pay at least double the price for fertilizer relative to farmers in Asia and the US (Heisey and Norton, 2007: Morris et al., 2007). The high seasonality of demand for fertilizer in rainfed systems and the bulkiness of the product lead to relatively slow stock turnover, considerable storage requirements, and high finance charges, resulting in risk for distributors and dealers.

On the demand side, high cost, combined with low agronomic efficiency, makes the use of inorganic fertilizers unprofitable for many farmers in Sub-Saharan Africa. Against this background, it is not surprising that most maize producing countries in Sub-Saharan Africa followed trends in Asia and chose to subsidize fertilizer sales up until the mid-1980s or even later, when fiscal crises curtailed or ended them (Heisey and Norton 2007). Extensive subsidies were fiscally unsustainable, and coupled with a parastatal input marketing system led to highly inefficient and inequitable fertilizer distribution.

Liberalization of fertilizer markets has been implemented to varying degrees across countries and with very mixed success. The liberalization of Kenya's fertilizer markets is considered to have been most successful (detailed in Ariga and Jayne 2010). After the elimination of fertilizer price and import controls in the early 1990s, national fertilizer consumption doubled by 2007. Survey data collected from 1997 to 2007 by Tegemeo Institute indicate that smallholder fertilizer use per hectare of maize cultivated grew by 34 percent. The distance traveled by farmers to the nearest fertilizer retailer declined dramatically, reflecting increased investment in fertilizer retailing by private dealers. Inflation-adjusted fertilizer marketing margins between Mombasa and inland markets have narrowed, and nutrient-to-grain price ratios at the farm gate have become more favorable. Despite these gains, there is considerable potential for further efficiency gains through improving soil and moisture management to enhance yield response to fertilizer on the demand side, and reducing distribution costs through investments in eroded rail, road, and port infrastructure on the supply side.

In contrast to Kenya, Ethiopia continues the state-led, package-based approach today. The Government of Ethiopia liberalized the fertilizer sector after the end of the Derg and by 1996 several private firms were importing fertilizer, and 67 private wholesalers and 2300 retailers had taken over a significant share of the domestic market (Spielman et al., 2010). However, the private sector rapidly exited within a few years of its entry, and was at first replaced by "private" holding companies with strong ties to the ruling party and then by cooperative unions. The parastatal, Agricultural Input Supply Enterprise, continues to be a major importer and distributor of fertilizer. In addition, since 1994, about 90 percent of fertilizer has been delivered on credit at below-market interest rates and guaranteed by regional governments, displacing sales from the private sector, including a substantial share sold on a cash basis.

Fertilizer consumption per ha has increased only marginally over the past decade, and there is evidence that many farmers have dis-adopted seed-fertilizer technology packages over time. A study of Ethiopian smallholders found that half of farmers surveyed reported that fertilizer arrived after planting, and one-third reported underweight bags (Bonger et al., 2004). Loan recovery, using extension agents and local officials, was generally successful until the collapse of maize prices in 2002 forced rescheduling that incurred significant fiscal costs. Spielman et al. (2010) conclude that although state-led policies have generated some positive impacts in Ethiopia, they also reduce the quality and timeliness of inputs services, limit farmers' options, incur hidden costs, and entail the risk of large fiscal outlays.

Xu et al.'s (2009) study in Zambia illustrates that, in the more remote areas, where farmers faced nitrogen-maize price ratios that were 20 percent higher than elsewhere, fertilizer use was profitable only for a minority of farmers. At the same time, fertilizer use was profitable for farmers in the more accessible areas only when its delivery was timely. Subsidized fertilizer under government programs in Zambia has often been distributed late. The authors report that government programs have also caused private traders to wait and see where subsidized fertilizer is being distributed before deciding where to distribute commercial fertilizer, exacerbating the problem of late delivery even for commercial fertilizer.

Smart Subsidies

The urgency of arresting soil nutrient mining combined with rising fertilizer prices in recent years have stimulated interest in ways to raise fertilizer use through a new generation of so-called smart input subsidies (Morris et al., 2007; World Bank, 2007; Minde et al. 2008; Dorward et al. 2008). Input subsidies are “smart” if;

- the crop productivity and food security benefits outweigh what might have been achieved through alternative investments (not only direct but also considering the opportunity costs of resources used)
- they stimulate investment in input distribution by private suppliers and agro-dealers and the development of a robust input distribution system
- they target farmers who would not otherwise use purchased inputs in areas were economic yield response to fertilizer can be achieved, and
- they have a clear exit strategy.

Input vouchers redeemable at private input dealers and targeted to farmers who use little fertilizer have been the main vehicle for implementing smart subsidies. Malawi’s is one of the most studied cases of subsidy and voucher programs. During the 1980s, the provision of subsidized seed, fertilizer and credit was tied to purchases by a parastatal marketing board. However, in 1995, prices of all inputs and crops except maize were fully liberalized and the extension service began promoting other crops and activities.

In 1996-97, in response to a crisis situation, the Starter Pack Initiative was introduced to “jump-start” maize production by providing enough seed and fertilizer for 0.1 ha of maize, and seed of other crops, for all smallholders. After several seasons of exceptionally good harvests, donors began to complain about the welfare nature of the scheme, urging its replacement with the Targeted Inputs Program (TIP). The TIP scaled down the number of beneficiaries and replaced hybrids with improved OPVs, which were viewed as more suitable for smallholders. Delayed deliveries, poor weather, and late maize imports led to high prices and increasing food scarcity during the 2001-2 season. A similar scenario occurred in 2005-6.

In response to the 2005/06 crisis, the government initiated the Agricultural Input Subsidy Programme (AISP). AISP provides about 50 percent of farm households with vouchers for 100kg of fertilizer and small quantities of maize (and lately legume) seed, with mainly privately imported fertilizers delivered principally, and in some years exclusively, by two parastatal input suppliers. During the 2005/06 season over one million input coupons were distributed for a fiscal cost of US$32 million. Since then the program has been scaled up each year to reach US$242 million in 2008/09, largely paid by the Government of Malawi. Corresponding to rising fertilizer prices, the subsidy paid 91 percent of fertilizer costs in 2008/09. The program has been perceived as a test case for potential implementation elsewhere in Africa.

Since the policy motivation for governments to subsidize fertilizer is to enable smallholders to attain higher maize yields, establishing positive impacts on productivity is fundamental. In an analysis of three years of plot-level data collected from 450 households in Central and Southern Malawi, Holden and Lunduka (2010a) found that access to subsidized fertilizer had a significant positive effect on maize yields. However, Dorward et al. (2010) concluded that the benefits of the program are difficult to assess due to controversies about national statistics on maize production, which are likely to be overestimated. With reasonable assumptions about maize yield response to fertilizer, the authors do find that the program has generated a positive, though modest benefit-cost ratio in three of the four years since the subsidy program was initiated.

Despite the reported increase in maize production, it is not clear that the program has enhanced food security. Domestic maize prices have been high in three out of four years of the program, incurring a major hardship for poor people, including the 60 percent of farmers who are net maize buyers. There is a tendency for the program to focus on production objectives and producer welfare, but to ignore consumers, and thus the conditions necessary for overall food security. Also, based on farm panel data over a 6 year period, Ricker-Gilbert and Jayne (2011) find that the receipt of the subsidy in multiple prior years had little enduring effect on recipient households' incomes or asset wealth after they stopped receiving the subsidy.

Targeting has posed continuous difficulties. Household surveys suggest that the 2006/7 program was highly variable across locations in terms of targeting criteria, but that there was a tendency to reach households which were productive full-time farmers. Female-headed and poorer households were less likely to receive coupons (Holden et al. 2010b). Holden and Lunduka (2010b) also report the presence of secondary markets for coupons—not from households that initially received the coupons, but from other leakages in the distribution system. The secondary market for fertilizer coupons also favored wealthier households. The authors ask whether targeting is more effective at reaching poor and vulnerable people than would be a general subsidy.

Given the type of household reached it is not surprising that the voucher program displaces commercial sales. If the voucher for subsidized fertilizer is received by a farmer who would otherwise have bought fertilizer at a commercial price, then the voucher program may shift the composition of retailer's profits from commercial fertilizer to subsidized fertilizer, with uncertain effects on the total quantity of fertilizer applied to the farmer's field. Ricker-Gilbert, Jayne and Chirwa (2011) found that the displacement rate is considerably lower among the poorest farmers. They report an overall displacement rate of commercial fertilizer by subsidized fertilizer of 0.29, meaning that each additional kilogram of subsidized fertilizer distributed under the government program contributes an additional 0.71 kilograms to total fertilizer use.

Some "crowding out" of commercial suppliers by government subsidy programs has also been demonstrated in Zambia, where an additional kilogram of fertilizer distributed under the subsidy program added 0.92 kg to the amount of fertilizer used by farmers (Xu et al. 2009). Where the private sector was already active, this leverage was only 0.12, suggesting that the subsidy program led to the withdrawal of some private retailers. By contrast, where fertilizer was targeted to areas where the private sector was inactive, and to poorer households, the leverage was as much as 1.7 kg per household, suggesting the potential for "crowding in."

As can be expected given the history of fertilizer subsidies in Sub-Saharan Africa, program sustainability continues as a major issue. The costs of the Malawi program have exceeded the planned budget and represented 72 percent of the total budget of the Ministry of Agriculture, and 16 percent of the national budget, in 2009. Mann's (2007) concludes that the AISP, similar to the subsidies of the 1980s, is too large to be sustained, and three times as costly as the earlier Starter Pack Program, which had achieved considerable success (but was rejected by donors as too expensive). Malawi and Zambia have implemented nearly continuous fertilizer subsidy programs each year for the past several decades and no feasible exit strategy is apparent.

Stabilizing Maize Markets

The price spikes in global grain markets during 2008 focused public attention on the vulnerability of the rural and urban poor to volatility in food and fertilizer prices, although these issues are by no means new. A compilation and review of empirical research in a conference sponsored by the World Bank (World Bank 2005; Byerlee, Jayne and Myers, 2006) led to several general conclusions regarding maize grain markets in Sub-Saharan Africa. First, poor producers and consumers in Africa, which include many smallholder farmers, are more exposed to sharp movements in the price of maize relative to those who depend on rice in Southeast Asia (Table 3). Second, landlocked countries in southern Africa that depend on maize are most exposed to domestic sources of shocks, as are other landlocked African countries, such as Ethiopia. In these countries, food production is highly variable, and national capacity to operate on world markets to smooth supply variability is limited by high transport costs and foreign exchange constraints. For example, maize prices in Ethiopia can fluctuate widely between import parity of $250 or more and export parity prices that may be as low as $50. Consistent net importers of maize with better infrastructure, such as Kenya, can smooth prices through trade, although they risk exposure to sharp spikes in world prices, as occurred in 2008.

Not surprisingly, the high level of price instability for a staple crop such as maize has invited efforts to stabilize prices, even during the post-structural adjustment period. Yet discretionary interventions in grain markets often reduce participation by the private sector in countries where reform from parastatal to market-led approaches remains incomplete. Maize markets are more volatile in Malawi than in other countries of southern Africa, despite the fertilizer subsidy and recorded production gains. Continued suspicion with respect to the capabilities and intentions of the private sector has led to greater involvement of the nation's parastatal, Agricultural Development and Marketing Corporation (ADMARC), in maize marketing. Tschirley and Jayne (2010) conclude that market shortages and stock-outs at ADMARC have sometimes led to huge price surges. However, there is growing private sector entry in maize marketing and encouraging evidence on the number of traders to whom farmers can sell maize and proximity to point of sales.

Over the past few decades in Kenya, synergies between the liberalization of the input and maize markets and public investments led to tangible investments by the private sector in not only seed and fertilizer retailing but also maize marketing (Ariga and Jayne 2010). Maize marketing margins have also contracted, as well as the distance traveled to the point of maize sale. However, maize sales remain highly concentrated among farmers. The Tegemeo Institute panel data confirm that less than two percent of the farms account for 50 percent of the overall marketed maize surplus from the smallholder sector. Most smallholders, which account for 96 percent of all the farm households in Kenya, were consistently buyers of maize in the three seasons for which data were collected (which included one good production year and two average years).

Kenya has pursued a policy of high food prices with import tariffs in the range of 25-50 percent and until 2005, restrictions on maize inflows from neighboring countries. The operations of the maize marketing board (NCPB) have raised the level of maize prices in the country by offering support prices well above market levels (Jayne et al. 2008). Grain price supports and/or stabilization policies that raise mean price levels over time will have income distributional effects that run counter to stated goals of reducing poverty. Mean-neutral forms of price stabilization would most likely avoid these adverse distributional effects, and by reducing risks, would also help to promote diversification toward higher-valued crops by maize-purchasing households (Fafchamps, 1992). Thus, the question for state maize price stabilization or price support is not whether these policies can generate positive benefits for surplus-producing farmers, but whether such benefits could reasonably be expected to exceed the costs of higher food prices for the majority of the population.

Over the long term there is a need to encourage the transition to market-based food systems and build capacity in private markets. Generalized measures to support market efficiency, such as investments in transport, storage, information systems and market regulations will serve to reduce the volatility of maize prices in Sub-Saharan Africa. To create space for private markets to operate, governments need a predictable, well-defined food security strategy that is implemented sequentially. For example, blanket subsidies and restrictions on grain trade, such as pan-territorial and pan-seasonal prices, would need to be removed for private traders to have an incentive to store and move grain from surplus to deficit areas.

Risk management instruments, such as warehouse receipts and futures and options markets offer another option. Futures and options markets are expanding rapidly in the developing world. South Africa has a well established exchange that other countries in the region can and sometimes do tap (Dana et al. 2005). Variable tariffs and small strategic grain reserves continue to receive some support as short-run, transition policies. Such market-oriented interventions should be backed by safety nets to deal with consequences of extreme prices on vulnerable populations.

The promotion of regional trade is one of the most effective “quick-wins” for reducing food price volatility in smaller countries (World Bank 2005). Regional production varies less than production in individual countries, and despite large and positive correlations in maize production among countries, there is generally scope for intra-regional trade in all but the worst years. Govereh et al. (2008) demonstrate that natural “marketsheds” span borders throughout Sub-Saharan Africa. However, for regional markets to function, countries need to agree to ban export restrictions in times of high prices and use other means to protect the vulnerable population.

Conclusions

Maize remains crucial for food security in Sub-Saharan Africa. In some regions, the predominance of the crop in farming systems and diets implies that yield gains have the potential to jump-start a Green Revolution like those experienced in Asia for rice and wheat. However, despite episodes of success, the evidence compiled here suggests that very little progress has been made toward achieving this potential since Byerlee and Eicher’s (1997) review. Moreover, while maize remains the most important food security crop for millions of rural households, chronic food insecurity persists even where progress in maize production has been achieved, as in Malawi and Ethiopia.

The fact that domestic maize production cannot keep up with the food requirements of expanding urban populations is reflected in the growing consumption of rice and wheat in cities and towns, most of which is imported. African smallholders are generally competitive in maize production, at least with imports, and import substitution and integrated regional markets provide ready markets for greater maize production. Demand for maize to feed livestock is expected to grow rapidly, further taxing food supplies.

Green Revolution-style intensification is expected to succeed best in the densely populated and relatively high potential areas such as the East African highlands, Malawi, and parts of Nigeria where maize is the dominant staple. Yet even in these areas, yield growth has been slow, and although the adoption of improved maize varieties has increased in many areas, it has often fluctuated as a consequence of policy shifts. In areas where improved maize varieties have been widely adopted, genetic yield gains are dampened by the use of old varieties. Use of fertilizers and other crop management practices remains limited. Combined with soil nutrient mining and degradation, this poses fundamental challenges in sub-Saharan Africa's rainfed production systems.

In many areas, too, access to land has become so constrained that surplus maize production is unattainable for many smallholders even with successful adoption of seed fertilizer technologies. A strategy to diversify maize production systems could provide higher returns to scarce land and improve food security, provided that retail maize markets are dependable. In semi-arid and more marginal environments, where the risk of drought is high, such a strategy will include suitable higher-value crops and livestock products.

Sub-Saharan Africa also has large areas of low population density that are suitable for expanding maize production and where it is not surprising that intensification technologies have not yet been adopted, given relative land abundance. In these areas, such as in much of the savanna and miambo woodlands, adoption of labor-saving technologies together with sustainable soil management practices will be the key to expanding the area under maize (World Bank, 2009). Many of these areas are relatively remote and appropriate public investments in infrastructure and technology, combined with private investment in commercial farming, offer the opportunity for Africa to be a major exporter of maize in the future.

Over the long term, large investments and sustained political commitment are needed to ensure strong plant breeding and seed systems to serve smallholders, predicated on improved crop management practices to protect soils and cope with unreliable rainfall, and access to appropriate labor-saving technologies. More innovative extension and advisory systems are also needed to facilitate farmer learning and adapt techniques and technologies to local environmental and social conditions. Better financial services, perhaps including new forms of insurance, are needed for smallholders.

Harder questions concern how these investments should be sequenced, and how they should be tailored to the highly heterogeneous, maize-based farming systems of Sub-Saharan Africa. This review has highlighted the importance in maize technical change of establishing and maintaining conducive policies. These are equally, if not more, important for agricultural transformation than seed, fertilizer and management practices. Although pockets of success are visible, policy reform has generally been incomplete and policy interventions, including donor priorities, have often been *ad hoc* and unpredictable. The new initiatives of this decade, founded on 'market smart' approaches, have strayed quickly from their original path, and are not likely to be sustainable. There is now a risk of repeating the mistakes of the 1970s and 1980s by focusing on silver bullets such as large-scale input voucher programs, rather than investing in a broad-based strategy for long run productivity growth.

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Table 1 Maize Area, Production, Yield and Consumption in Regions of Sub-Saharan Africa, 1961-2008

	Western Africa	**Central Africa**	**Eastern Africa**	**Southern Africa[a]**	**Sub-Saharan Africa[a]**	**South Africa**
Maize area (million ha, 2005-2008)	7.75	2.31	7.79	6.99	24.84	2.46
Maize production (million tons, 2005-2008)	12.86	2.42	11.62	7.62	38.21	8.55
Maize yield (2005-2008)	1.66	1.05	1.49	1.09	1.39	3.45
Growth in maize area (%/yr, 1961-2008)	3.09	1.92	1.84	1.30	2.03	-0.89
Growth in maize production (%/yr, 1961-2008)	4.80	2.90	3.02	1.30	2.99	0.98
Growth in maize yields (%/yr, 1961-2008)	1.71	0.98	1.18	0.00	0.95	1.87
Average kg/cap/year (2003-2005)	24.4	24.9	26.9	81.8	39.6	104.2
Average percent of calories/cap/year (2003-2005)	8.6	12.4	19.3	36.1	19.1	30.8

a Excludes South Africa. Source: FAOSTAT. See Appendix 1 for country classification used in this table.

Table 2 Variability in Maize and Rice Yields and Prices around Trend in Major Maize Producing Countries Compared to Rice in Asia, 1991-2007.

Country and Region	CV of yield*	CV of producer price
	(%)	(%)
Africa—Maize		
Ethiopia	14.5	23.2
Ghana	7.2	37.6
Kenya	11.1	19.5
Malawi	32.9	39.3
Mozambique	23.8	22.0
Nigeria	6.5	20.6
South Africa	20.3	28.6
Tanzania	11.2	na
Uganda	8.2	na
Zambia	30.6	na
Zimbabwe	40.9	na
SE Asia—Rice		
Cambodia	7.2	24.8
Indonesia	2.1	24.2
Laos	4.1	15.4
Malaysia	3.8	9.0
Myanmar	3.0	na
Philippines	5.5	7.0
Thailand	3.0	15.7
Global		
Maize	1.3	13.4
Rice	3.3	19.9

Source: Computed from the standard error around a linear time trend, divided by the mean for the period.

Table 3 Staple Food Budget Shares, Urban Centers in Kenya, Mozambique, and Zambia

Urban center	Year	Percent of food group in total value of consumption of main staples[a]				Percent of the four main staples in total food consumption
		Maize	Wheat	Rice	Cassava	
Nairobi, Kenya	1995	42.4	35.3	22.4	0.0	–
	2003	36.3	39.0	24.7	0.0	28.4
Urban Maputo	1996	2.6	50.7	35.0	11.7	42.8
Province	2002	8.9	57.4	28.9	4.8	27.0
Urban Northern Mozambique (includes Nampula city)[b]	2002	32.6	8.2	14.7	44.4	47.5
Lusaka, Zambia[c]	2007/8	39.0	49.4	10.7	0.9	19.5
Kitwe, Zambia[c]	2007/8	42.5	45.3	10.3	2.0	23.2
Mansa, Zambia[c]	2007/8	45.8	28.2	10.0	16.0	23.8

Source: Mason et al.(2011)

Notes:

[a]Main staples refers to maize, wheat, rice, and cassava. Budget shares of these four staple foods sum to 100 percent +/- 0.1 percent. Shares for Nairobi and northern Mozambique are the percentage of total food purchases.

[b]Cassava category also includes potatoes for urban northern Mozambique (separate figures for cassava only not available).

[c]Excludes foods purchased and consumed away from home – information not available.

Table 4 Adoption of Improved Maize Varieties (% of Maize Area) in Eastern and Southern Africa, 1990, 1996 and 2006

	2006				1996				1990		
	Improved OPV	Hybrid	Modern maize	Adjusted for saved seed	Improved OPV	Hybrid	Modern maize		Improved OPV	Hybrid	Modern maize
Eastern Africa	7	26	33	37	6	26	32		15	25	40
Ethiopia	5	14	19	21	3	5	8		16	5	21
Kenya	4	68	72	74	9	62	71		8	62	70
Tanzania	6	12	18	22	2	2	4		12	6	18
Uganda	21	14	35	54	4	4	9		50	10	60
Southern Africa	9	29	38	52	4	22	26		6	42	48
Angola	4	1	5	10	11	0	11		--	--	--
Malawi	15	7	22	50	1	13	14	(37)	3	11	14
Mozambique	10	1	11	22	9	0	9		17	1	18
Zambia	4	69	73	81	1	22	23		5	72	77
Zimbabwe	6	74	80	93	0	82	82		0	96	96
Eastern and Southern Africa	10	25	35	44	4	23	28		10	33	43

Source: Langyintuo et al. (2008), Hassan et al. (2001), Lopez-Pereira and Morris (1994).
Note: Langyintuo et al. (2008) adjust the actual seed sales in 2006/7 by improved OPV sales in previous two seasons for adjusted adoption rate.
For both sources, improved OPV and hybrid rates are calculated as percent of seed sales. Hassan et al. include Tanzania in Southern Africa, and also include Lesotho (71%) and Swaziland (78%), but exclude South Africa (96%). Including South Africa, they calculate that the adoption rate for Southern Africa in 1996 is 47% and 43% for Eastern and Southern Africa. No data are reported for Angola in 1990. The second figure for Malawi is estimated by Smale and Phiri (1997) based on official area estimates. Seed sales estimates are lower.

Table 5 Adoption of Improved Maize Varieties (% of Maize Area) in Western and Central Africa, 2005, 1998, and 1981.

	2005	**1998**	**1981**
West and Central Africa	60	37	4
Benin	41	25	3
Burkina Faso	75	46	3
Cameroon	44	28	8
Cote d'Ivoire	52	--	4
Ghana	89	53	1
Mali	38	23	3
Nigeria	61	40	6
Senegal	95	89	4

Source: Alene et al; (2009), Manyong et al. (2003)
Note: Authors estimate that over 95% of modern maize
planted in West and Central Africa is improved OPV, based on breeder surveys in each year, similar to those conducted by CIMMYT sources in Table 8.5
No data are reported for Cote d'Ivoire in 1998.
Manyong et al. include Togo (1.3%), Chad (70%) ,
DR of Congo (31%) and Guinea (23%) in the regional adoption rate.

Annex 1. Country classification used to analyze FAOSTAT data

The country classification used in this paper differs from that used by FAOSTAT, with the exception Western Africa. Data were loaded for each country and summarized according to the following classifications:

Eastern Africa	Southern Africa	Western Africa	Central Africa
Burundi	Angola	FAO	FAO without Angola
Comoros	Botswana		
Eritrea	Lesotho		
Ethiopia	Malawi		
Kenya	Madagascar		
Mauritius	Mozambique		
Reunion	South Africa		
Rwanda	Swaziland		
Somalia	Zambia		
Tanzania	Zimbabwe		
Uganda			