Agricultural Productivity and Food Security In Sub-Saharan Africa

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Abstract: Patterns of agricultural productivity growth in Sub-Saharan Africa are mixed. Most of the variation between countries in the region is due to differences in the application of conventional inputs, especially labor, but further gains from increased labor application are likely to be limited. Many countries in Sub-Saharan Africa still have considerable potential to raise productivity through increased use of other conventional inputs, such as fertilizer. Realizing such increases, however, will depend on additional investment in roads, education, research, and (in some areas) the cessation of armed conflict.

Introduction

Agriculture is the principal source of food, livelihood, and foreign exchange earnings in Sub-Saharan Africa (SSA) (Badiane and Delgado, 1995). Over the next 10 years, the region's food needs are projected to grow rapidly, driven by a population growth rate of 2.5 percent per year, the world's highest (World Bank, 1998). Although expansion of agricultural land has contributed much to increased agricultural production in the past, continued area expansion is likely to involve increasing economic and environmental costs (Crosson and Anderson, 1995). Growth in agricultural productivity remains critical to SSA's ability to meet food security and economic development objectives.

Yet evidence of agricultural performance in SSA is mixed at best (table A-1). *Total factor productivity* in agriculture (see "Definitions") is estimated to have grown an average of 1.3 percent annually between 1961 and 1991 for Africa as a whole (Lusigi and Thirtle, 1997). *Land productivity* in SSA agriculture rose an average of 1.9 percent per year between 1980 and the mid-1990s, while increasing 3.4 percent and 2.0 percent annually in South Asia and Latin America and the Caribbean, respectively (World Bank, 1998). Over the same period crop production in SSA grew 2.7 percent per year, and food production grew 2.4 percent per year. By contrast, *labor productivity* fell an average of 1.0 percent per year in SSA agriculture, while increasing 1.9 percent and 2.5 percent per year respectively in South Asia and Latin America and the Caribbean.

Complicating the differences in these indicators of agricultural productivity at the regional level are differences in the level and rate of change in each indicator across subregions and countries within SSA. Understanding these differences, and the various factors that generate them, is critical to determining how policy measures can best improve agricultural productivity.

Different Measures of Productivity Have Different Implications for Food Security

Different measures of agricultural productivity are explained in the "Definitions" box. In brief, each indicates the level of agricultural output per unit of a particular input or set of inputs. Distinguishing different measures of productivity is important. Output per unit of land, or crop yield, is commonly used by agricultural scientists or by national policymakers to assess agricultural production for meeting national food security needs. Output per agricultural worker, on the other hand, may be a more important indicator of rural standards of living and welfare (Block, 1995). As such, labor productivity may be particularly important as an indication of the ability of agricultural workers to acquire sufficient food, regardless of whether they produce food themselves. Thus labor productivity is linked to food security at the household level. By contrast, total factor productivity (TFP) controls for changes in the levels of multiple inputs, and is thus suited to assessing the impact of technical change in agriculture.

It is also important to distinguish sources of change in the productivity of a given input or set of inputs over time. The productivity of a particular input, such as land, may change for a variety of reasons. For example, agricultural output per unit of land (i.e. land productivity) in a particular area might increase due to adoption of improved seed varieties, expansion of irrigation, or increased fertilizer use. Increased labor application on a fixed land area would also be expected to increase land productivity (at least over a particular range). However, the increase in output would be expected eventu-

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Table A-1--Agricultural Productivity Levels and Trends

	Land productivity		Labor productivity		Ag. land	Total factor productivity	
	$/hectare (1993)	Growth rate (1980-93)	$/worker (1995)	Growth rate (1980-95)	Ha/worker (1993)	Index (1991)	Growth rate (1961-91)
Sub-Saharan Africa	68	2	392	-1.0	6.0	0.8 1/	1.3 1/
South Asia	519	3	383	1.9	0.8	na	na
Latin America & Carib.	116	2	2,292	2.5	17.0	na	na
Central Africa							
Cameroon	313	2	827	-0.3	2.6	0.9	1.8
Central African Rep.	119	2	516	0.8	4.2	0.6	2.7
Congo	28	2	629	1.0	21.6	0.9	1.2
Gabon	74	1	1,516	0.5	22.3	0.3	-2.3
Zaire	113	2	219	0.0	1.9	0.6	8.1
East Africa							
Burundi	270	2	177	-1.4	0.8	2.9	3.4
Ethiopia	116	na	181	na	1.5	0.2	-1.7
Kenya	90	2	240	-0.7	2.7	0.6	1.9
Madagascar	34	2	178	-0.4	5.3	0.7	-0.1
Rwanda	378	-1	206	-2.6	0.7	0.7	6.1
Uganda	515	na	592	na	1.1	2.9	7.8
Sahel							
Burkina Faso	93	3	182	1.1	1.9	0.1	0.8
Chad	10	4	198	2.0	20.3	0.6	0.2
Gambia	199	2	167	-1.7	0.9	0.4	-1.5
Mali	33	3	259	0.2	7.6	0.8	0.8
Mauritania	7	3	na	na	na	0.1	-0.3
Niger	63	1	256	-0.9	3.9	0.7	1.5
Senegal	118	2	375	0.9	3.0	0.6	1.5
Somalia	na	na	na	na	na	0.8	1.2
Sudan	na	na	na	na	19.1	0.8	0.1
West Africa							
Benin	321	4	563	2.8	1.6	1.1	1.2
Ghana	227	0	684	-1.1	2.9	0.7	-0.5
Guinea	54	na	225	na	4.1	0.5	1.2
Guinea-Bissau	78	3	292	3.1	3.4	0.1	-2.1
Ivory Coast	212	1	1,354	-0.8	6.2	1.1	0.9
Liberia	na	na	na	na	na	1.1	0.0
Nigeria	150	2	684	2.4	4.4	0.6	-0.3
Sierra Leone	123	0	344	-0.4	2.7	0.5	0.5
Togo	189	4	461	0.9	2.6	0.4	-1.3
Southern Africa							
Angola	9	na	149	na	16.5	0.4	-0.8
Botswana	5	2	483	1.4	102.4	0.2	1.3
Lesotho	24	-3	194	-2.7	7.5	0.1	-1.7
Malawi	153	0	156	-0.3	0.9	0.7	0.3
Mozambique	12	na	92	na	6.9	0.3	0.3
Namibia	9	1	1,458	0.8	136.1	1.4	1.0
South Africa	49	1	2,870	1.3	51.0	1.4	1.3
Swaziland	na	na	na	na	na	1.2	3.3
Tanzania	na	na	na	na	3.2	0.4	0.2
Zambia	7	1	100	-1.0	14.7	0.5	1.5
Zimbabwe	41	2	266	-0.7	6.0	0.7	2.0

na = not available. 1/ These averages are for all of Africa.

Sources: World Bank (1998), Lusigi and Thirtle (1997).

ally to diminish as more and more labor is applied to a fixed land area.[2] If the percentage increase in output is less than the percentage increase in labor, labor productivity could well be falling while land productivity is increasing. Distinguishing sources of change in the productivity of a given input is important because it improves our understanding of how policy might generate additional increases in returns to that input. We look next at levels and changes in three measures of agricultural productivity, and then at some of the factors that drive those changes.

Trends in Agricultural Productivity Are Mixed

Land productivity averaged US$68 per hectare of agricultural land for SSA as a whole in 1993, compared with $519 in South Asia and $116 in Latin America and the Caribbean (table A-1). Values ranged from $5 to 10 per hectare in the drier countries of Southern Africa and the Sahel to $200 per hectare and more in the East African highland countries and tropical West Africa. For SSA as a whole, land productivity grew an average of 1.9 percent per year between 1980 and 1993, with slow to moderate growth in most countries. Land productivity grew most rapidly in the Sahelian countries and West Africa, and more slowly in Eastern and Southern Africa (see also figure A-1).

Labor productivity averaged $392 per agricultural worker for SSA as a whole in 1995, compared with $383 in South Asia and $2,292 in Latin America and the Caribbean. Values ranged from $100 to 200 per worker in many countries in Eastern and Southern Africa and the Sahel to more than $500 per worker in parts of West and Central Africa. Labor productivity declined an average of 1.0 percent per year for SSA as a whole between 1980 and 1995, with modest growth in parts of Western and Southern Africa (see also figure A-1).

As noted previously, low (or declining) labor productivity is consistent with high (or growing) land productivity in the context of a large (or expanding) agricultural labor force. Such patterns are evident in the data on agricultural land per worker presented in table A-1. The land/labor ratio is generally low in East Africa and high in Central and Southern Africa and the Sahel. Within regions, low land/labor ratios are generally associated with high land productivity (as in Rwanda, Gambia, Benin, and Malawi), while high land/labor ratios are generally associated high labor productivity (as in Gabon, Ivory Coast, and Namibia).

[2]The "almost universal" *law of diminishing marginal product* (Henderson and Quandt, 1980, p. 68) describes the relationship between the level of output of a particular commodity and the level of a particular input as the latter changes while the level of other inputs remains fixed. The pattern typically exhibited by this relationship is one in which, after a point, the incremental increase in output generated by continuing increases in a single input begins to diminish (all other inputs being fixed). The law does not apply if all inputs are increased proportionately.

Land and labor productivity are both incomplete measures of agricultural productivity, since they measure the productivity of only a single factor of production, and may well move in opposite directions or conceal negative growth in broader productivity measures. In an effort to address this problem, economists estimate total factor productivity, which measures changes in agricultural output relative to changes in an aggregated index of multiple inputs. Table A-1 reports estimates by Lusigi and Thirtle (1997) of total factor productivity levels for 1991 and rates of change for 1961-91.[3] The TFP index is normalized to 1.0 for the most efficient countries in 1961. For Africa as a whole, the TFP index averaged 0.8 in 1991, up from 0.7 in 1961. This indicates that even though productivity has risen on average, many SSA countries were still not as efficient in 1991 as the most efficient countries were in 1961. TFP levels are mixed in each region, with the highest estimates in parts of Southern, Western, and Eastern Africa (particularly Uganda and Burundi). Uganda and Burundi are also among the countries with the highest rates of growth in TFP (see also figure A-1).

Changes in TFP are, by definition, driven by changes in factors that are not incorporated in the index of inputs constructed to estimate TFP. For example, TFP growth could reflect factors such as technical change or improvements in infrastructure or research. On the other hand, it could also reflect factors such as unmeasured depletion of soil or other natural resources, with very different implications for sustainability and food security. Identifying these sources of change is thus critical to designing appropriate policy responses.

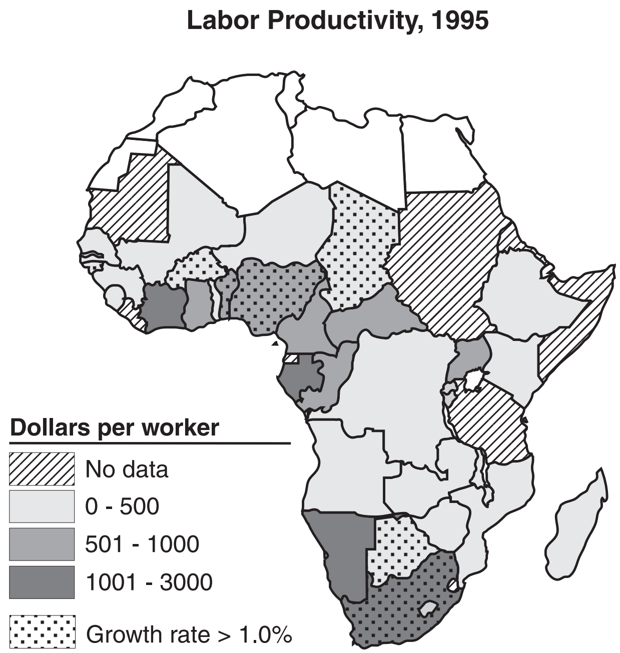
Productivity Is Affected by Many Factors

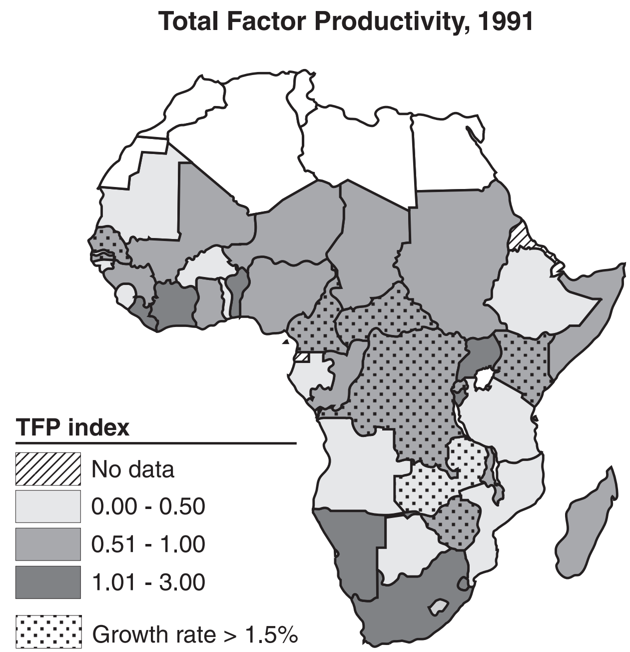
We are interested in differences in agricultural productivity levels and growth rates across countries in SSA in order to better understand those factors that are particularly influential in generating or impeding productivity growth. Five recent studies have examined agricultural productivity in Africa and other developing countries, and are summarized in table A-2.

Frisvold and Ingram (1995) examine land productivity for 28 countries in four regions of SSA between 1973-75 and 1983-85. Land productivity was estimated to have grown at an annual rate of 1.5-1.8 percent in most regions over the period. Frisvold and Ingram found that increased application of agricultural labor was the single most important factor in explaining growth in land productivity, and concluded that substantial increases in land productivity should not be expected until land becomes relatively scarce, echoing

[3]Several recent studies have presented Malmquist TFP indexes for various sets of countries (Fulginiti and Perrin, 1997; Lusigi and Thirtle, 1997; Trueblood and Coggins, 1997). We choose to present the results of Lusigi and Thirtle, since theirs is the only study that focuses exclusively on Africa.

Figure A-1--Productivity in Sub-Sahara Africa





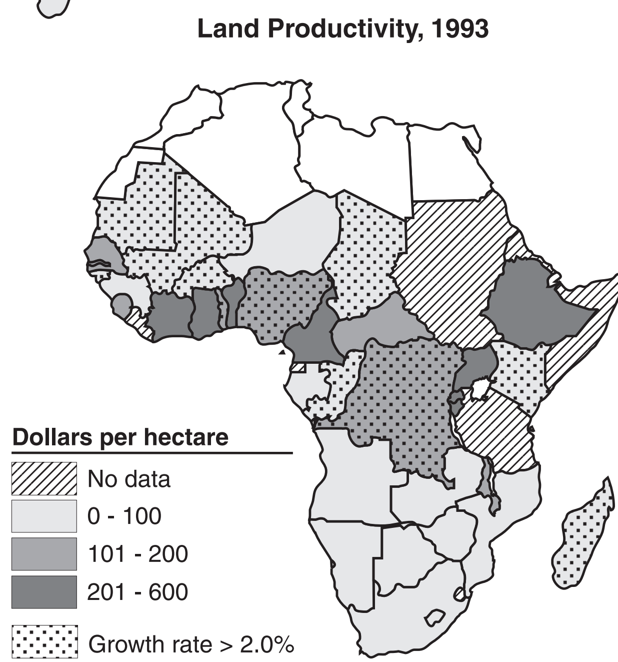


Table A-2-- Key Studies and Findings

Study	Countries	Time	Key findings
Frisvold & Ingram (1995)	28, in 4 SSA regions	1973-75 to 1983-85	Land productivity grew 1.5-1.8 percent per year in most regions, due mostly to increased labor input.
Craig, Pardey, & Roseboom (1997)	67, including 24 SSA and South Africa	1961-1990	Cross-sectional differences in labor productivity are explained mostly by conventional inputs; input quality and public infrastructure also matter.
Lusigi & Thirtle (1997)	47 African	1961-91	TFP grew 1.3 percent per year on average; noted role of population density.
Block (1995)	39 SSA	1973-88	TFP growth increased from -0.5 percent per year in the ‘70s to 1.6 percent per year in the ‘80s, mostly due to agricultural research and macroeconomic policies.
Thirtle, Hadley, & Townsend (1995)	22 SSA	1971-86	Low but positive TFP growth; significance of infrastructure, research, extension, education, and policy.

Binswanger and Pingali (1988) and Boserup (1965). Growth in the stock of *conventional inputs* (such as labor and machinery; see “Definitions” box) accounted for more than two-thirds of growth in land productivity, which in turn accounted for the majority of growth in agricultural output. *Nonconventional inputs* (such as land quality and historic calorie availability) were significant in explaining land productivity variation across countries, but did not contribute significantly to land productivity growth over time in most regions. Although agricultural research is often aimed specifically at improving yields, Frisvold and Ingram found no significant relationship between agricultural research expenditures and land productivity.

Labor productivity was examined in a study of 67 developing countries, including South Africa and 24 other SSA countries, by Craig, Pardey, and Roseboom (1997). They found that conventional inputs explain nearly three quarters of the variation in labor productivity across countries. Variables that adjust for quality differences in land and labor (rainfall, share of land that is arable, share of land that is irrigated, and life expectancy), and the amount of publicly provided infrastructure (including roads and agricultural research expenditures) are also significant in explaining cross-sectional differences in labor productivity.

Lusigi and Thirtle (1997) estimated an average rate of TFP growth of 1.3 percent per year for 47 African countries during 1961-91. They found that conventional inputs, land quality, and research expenditures together explain almost three-quarters of variation in production across the countries studied. Like Frisvold and Ingram (1995), Lusigi and Thirtle stress the contribution of population pressure to faster growth, arguing that land abundance depresses farmer incentives to increase land productivity by adopting yield-increasing technologies.

Block (1995) finds rates of growth in agricultural TFP in 39 SSA countries increasing from -0.5 percent per year (for 1973-78) to 1.6 percent per year (for 1983-88). Block suggests that expenditures for agricultural research and improved economic incentives (through improved macroeconomic policies) together explain two-thirds of measured productivity growth in SSA during 1983-88. This finding raises concerns about current reductions in public spending on agricultural research in SSA.

Thirtle, Hadley, and Townsend (1995) decompose the low but positive TFP growth rate they find for 1971-86 in most of the 22 SSA countries they studied into technical progress (from the time series for this panel of countries) and efficiency change (from the cross-section). Investments in infrastructure, extension, and the level of real protection on international agricultural markets are shown to be significant in explaining efficiency change, while tractors, the labor/land ratio, research and development (R&D), and secondary education are found to explain the variation in technical progress. They find the labor/land ratio, or population density, to be the single most important explanatory variable, again suggesting that productivity growth will accelerate in land-abundant countries as population density increases.

While the precise effects of different factors on the various measures of agricultural productivity vary from one study to the next, one broad pattern is clear. The studies are nearly unanimous in attributing most historic productivity growth to increases in the use of conventional inputs, especially labor. Policy reform, infrastructure, and agricultural research also make important contributions to productivity, although the estimated magnitude of these contributions is sensitive to the precise ways in which these variables are measured and analyzed.

Policy Reforms and Investment in Infrastructure and Research Are Keys to Productivity Growth

The studies reviewed here provide a guide to the factors that have historically affected agricultural productivity in SSA. Differences in the application of conventional inputs—especially labor—explain most of the historic variation in productivity between countries in SSA. Evidence of declining labor productivity and the costs of continued expansion of agricultural land, however, suggest that potential productivity gains yet to be realized from increased labor application are limited. Nevertheless, it is apparent that many countries in SSA still have considerable potential to raise productivity through increased use of other conventional inputs, namely fertilizer, machinery, and livestock. It has been argued that barriers to increased use of these inputs include lack of appropriate infrastructure and poor policy environments (Byerlee and Heisey, 1997; Heisey and Mwangi, 1996; Larson and Frisvold, 1996).

However, studies of historic productivity trends in SSA may provide incomplete guidance for future productivity growth. Analysis of a wider sample of countries with higher productivity may provide additional useful information on factors that could improve productivity in the future. In a review of such studies, Trueblood (1991) reports that the variables found to consistently affect productivity over a wide selection of countries include education, infrastructure, and research. For example, improved infrastructure may lead to increased productivity through enhanced access to output markets as well as through reduced costs for inputs such fertilizer and extension services. Investment in education and research may provide complementary increases in the efficiency with which fertilizer and extension services are used.

Given the importance accorded to physical infrastructure and education as nonconventional inputs in other multi-country studies of agricultural productivity (Craig, Pardey, and Roseboom, 1997) as well, it is surprising that these variables have not been included in the studies exclusive to Africa. It may be that data on infrastructure are not available for a large set of African countries. In an earlier study of agricultural productivity, Antle (1983) concluded that infrastructure investments help improve agricultural productivity in developing countries. In addition, a study of agricultural productivity in the United States has shown that infrastructure investments made important contributions to agricultural productivity through the 1960s (Shane, Roe, and Gopinath, 1998). Since that time, however, public and private R&D have become more important in spurring productivity growth in the United States. If a similar trend holds for other countries, we would expect that, for countries where the infrastructure is not yet well developed (as in much of Africa), large increases in agricultural productivity may be possible from investments in rural roads and utilities. It should also be noted that studies that include research as an explanatory variable but leave out infrastructure and other important nonconventional variables may be overstating the importance of research. It is for this reason that Block (1995) stresses that his estimate of research explaining up to one-third of the growth in TFP is an upper limit.

A few studies have looked explicitly at policy reform as an explanation for productivity growth. Block (1995) found that countries that depreciated the real exchange rate—and thus increased the prices paid to farmers for export crops—tended to have higher growth rates of total factor productivity. Fulginiti and Perrin (1997) used nominal price protec-

Definitions

Agricultural productivity is the amount of agricultural output per unit of input used in agricultural production.

Land productivity is the amount of agricultural output per unit of land used in agricultural production. Growth in land productivity reflects the growth in agricultural output not accounted for by (i.e. above and beyond) the growth in the amount of land used in agricultural production.

Labor productivity is the amount of agricultural output per unit of labor input used in agricultural production. Growth in labor productivity reflects the growth in agricultural output not accounted for by (i.e. above and beyond) the growth in the amount of labor used in agricultural production.

Total factor productivity (TFP) is the ratio of agricultural output to an index of inputs used in agricultural production. The inputs included in the denominator of the TFP index are typically the conventional inputs to agricultural production. The growth in agricultural TFP thus reflects the growth in agricultural output not accounted for by (i.e. above and beyond) the growth of conventional inputs.

Agricultural output is the sum of outputs of the agricultural sector, aggregated in monetary terms, less the cost of intermediate inputs.

Conventional inputs to agricultural production include land, labor, machinery, livestock, and fertilizer.

Nonconventional inputs to agricultural production include physical and institutional infrastructure, education, agricultural research and extension, and government programs and policies.

Data Limitations and Concerns

Data on agricultural inputs and outputs are costly to collect. Sub-Saharan African countries have limited budgets devoted to data collection, with the result that data on both conventional and nonconventional inputs are often unavailable or incomplete. Even for conventional inputs, data are often limited to large-scale, commercial, and/or more capital-intensive agricultural production rather than the smallholder sector that employs most of the region's agricultural labor force and produces most of the region's food.

These limitations are of concern because the more inputs that are unmeasured or incompletely measured, the fewer are the inputs that can be included in analyses of agricultural productivity, and the poorer are the estimates of the productivity of those inputs that are measured and analyzed. Lack of good estimates of the productivity of various inputs limits the ability of government and international agencies to establish policies that seek to achieve sustainable resource use, food security, and other objectives in the most cost-effective manner.

tion as a proxy for policy reform and concluded that countries that tax agriculture the most tend to have the most negative rates of productivity change. Recent World Bank findings suggest that countries with the most appropriate policy environments have experienced the highest levels of economic growth in SSA in recent years.

Other variables that deserve closer attention in studies of agricultural productivity include changes in resource quality over time and measures of political and institutional instability. Recent analysis indicates that changes in input quality accounted for one tenth of productivity growth in U.S. agriculture between 1948 and 1994 (Ahearn et al., 1998). Peterson's (1987) useful land quality index, which controls for irrigation, precipitation, and soil nitrogen, has been used frequently in international agricultural empirical work, but provides only one (constant) number per country that fails to reflect possible changes in land quality over time. If a portion of growth in agricultural productivity is actually due to soil fertility depletion, but soil depletion is left as an unmeasured explanatory variable (see box, "Data Limitations..."), growth in productivity may be incorrectly attributed to one of the variables that *is* measured and included in the analysis. As for measures of political instability, Messer, Cohen, and D'Costa (1998) estimate that cessation of armed conflict would have added 2 to 5 percent annually to Africa's per capita food production since 1980.

Improved Food Security Will Require Accelerated Productivity Growth

Almost three-quarters of the variation in agricultural productivity in SSA is explained by the use of conventional inputs, and research suggests that there remains significant scope to improve productivity in many countries through increased use of fertilizer, machinery, and livestock. Analysis elsewhere in this report projects that food production in SSA will grow an average of 2.3 percent per year over the next decade through a combination of area expansion (1.3 percent per year) and yield increases (1 percent per year). This report also projects that food production in SSA would have to grow 3.3 - 4.5 percent annually to meet a range of food security objectives over the next decade. If we further incorporate the World Bank's recommendation (Cleaver and Schreiber, 1994) that agricultural area expansion in SSA be limited to 0.5 percent per year on sustainability grounds, the need for gains in agricultural productivity growth becomes even more urgent. How might such gains be realized?

The studies reviewed indicate that continued growth of the agricultural labor force of 2.5 percent per year (World Bank, 1998) can be expected to increase agricultural output about 1 percent per year. As land becomes increasingly scarce relative to labor, farmers will increasingly seek ways to augment land through increased application of other inputs as well. Fertilizer application rates have been declining in SSA by an average of 1.3 percent per year since 1980 (World Bank, 1998). Reversing this trend and increasing fertilizer use by 5 percent per year could increase agricultural output by an additional 0.5 percent per year. Proportionate increases in the use of machinery and in research expenditures could be expected to add similar increases to output. Expected increases in output from improved infrastructure and price policies are difficult to quantify, but such improvements are also necessary to make possible the increases in productivity from conventional inputs and research.

In sum, agriculture in SSA is characterized by multiple constraints on accelerated productivity growth. On the one hand, this suggests that there are many means by which such constraints could be alleviated. For example, productivity gains from increased use of conventional inputs, such as fertilizer, could be supported through measures to improve smallholders' access to credit. On the other hand, in the absence of broad improvements in physical infrastructure, political stability, and the institutional environment, the returns to any single intervention in isolation are likely to be limited as other constraints quickly become binding. Policy reforms directed at improving physical and institutional infrastructure may not only increase use of inputs by lowering prices, but may also improve farmgate prices of agricultural output and thus more directly stimulate output. In addition, education of the rural labor force as well as agricultural research will improve the future prospects for productivity growth in SSA. Finally, the full benefits of research are unlikely to be realized before these more basic constraints are surmounted. Nevertheless continued investment in research (along with attention to more basic sources of productivity growth) remains important due to potentially long lags in application.

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