Forces Shaping Food Security: Factors Affecting Production

In recent decades, about half of all gains in crop yields have been attributed to increased use of conventional inputs, especially fertilizer and irrigation water; the remainder was due to genetic improvements in seeds. In the most food-insecure countries, however, expansion of land continues to play a key role in food production growth. (Stacey Rosen and Margriet Caswell)

Aggregate Trend In Per Capita Grain Production Was Negative During 1990-2003

Grains comprise the largest share of the diet in the developing world. In East and Southeast Asia, grains account for around 60 percent of calories consumed, on average. In Sub-Saharan Africa, this share is nearly 50 percent. In many of these countries, domestic production accounts for most of the grain supply as foreign exchange constraints limit imports. In this section, we examine trends in grain production, its contribution to consumption, and factors affecting its growth.

Growth in crop production stems from three sources: expansion of arable land, increase in cropping intensity (i.e., multiple cropping), and growth in yields. According to FAO, 80 percent of future production growth in developing countries will come from higher yields. Expansion of arable land will continue to play an important role in Sub-Saharan Africa and Latin America, albeit a much smaller role than in the past. However, most of the land with crop production potential not already used is in a few countries: Brazil, DR Congo, Sudan, Angola, Argentina, Colombia, and Bolivia. Moreover, some of this land is low quality or relatively inaccessible due to a lack of infrastructure. Therefore, productivity of the land would be poor or would require tremendous investment to make it more productive. There is almost no land available for expansion of agricultural activities in South Asia or North Africa.

Between 1990 and 2003, annual growth in grain production was highest in Sub-Saharan Africa at 2.4 percent, followed by Asia (1.8 percent), North Africa (just under 1.7 percent), and Latin America (1.4 percent). In the Commonwealth of Independent States (CIS), dramatic changes in the political landscape resulted in a sharp drop in output through 1998. Since then, production has rebounded and is approaching the levels achieved prior to the breakup of the Soviet Union. The production growth in Sub-Saharan Africa is surprising in that the region is characterized by food security issues. For that reason, these data need to be examined in more depth.

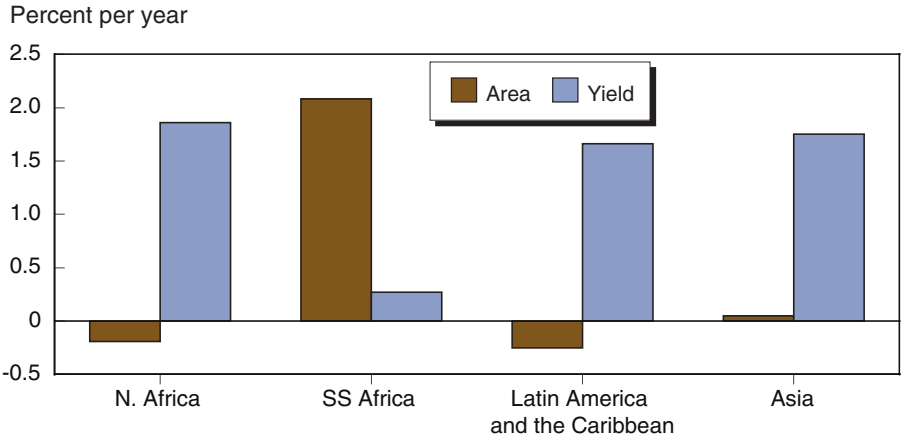
Population growth, which varies widely across these regions, must be factored into these growth trends. Since Sub-Saharan Africa has the highest population growth of all the regions (2.6 percent per year), its **per capita** grain production actually dipped between 1990 and 2003. In fact, negative per capita grain production characterized all the regions, some more than others.

In Sub-Saharan Africa, nearly 90 percent of the growth in grain production was achieved through area expansion (fig. 2-1). In the other regions, yields were the driving force. In Asia, for example, area expansion drove only 3 percent of production growth. In the other regions, the area used for grain production actually declined between 1990 and 2003, meaning that all growth was derived from yield gains. In addition to having the highest absolute level of yields, North Africa has had the highest gains in yields—growing nearly 2 percent per year since 1990. The high regional yields are principally due to production in Egypt, where most of the area is irrigated and grain yields are among the highest in the world.

Asia's yield growth is not far below that of North Africa—1.75 percent annually since 1990. In addition, the region's yields are approaching those in North Africa (fig. 2-2). This success has been driven largely by Vietnam and Bangladesh. In Vietnam, fertilizer use jumped more than threefold between 1990 and 2002. As a result, yields of rice—the staple crop in the

Figure 2-1

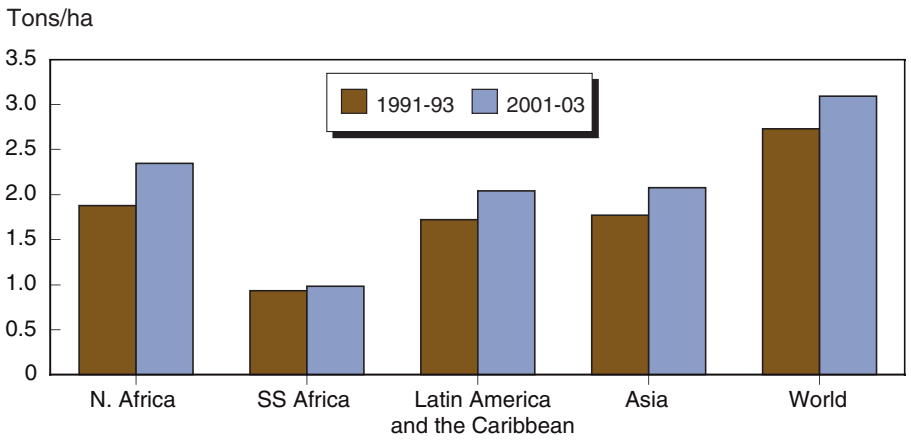
Yield growth is principal source of grain production growth except for SSA



Source: Economic Research Service, USDA.

Figure 2-2

SSA grain yields lag other world regions



Source: Economic Research Service, USDA.

country—average 4.6 kg per hectare, compared with the world average of less than 4 kg. In Bangladesh, irrigated area and fertilizer use both increased 50 percent between 1990 and 2002. Consequently, the country's rice yields, which were 70 percent of the world average as recently as the mid-1990s, now nearly match those levels.

Yield growth in Latin American and the Caribbean averaged 1.6 percent per year since 1990, an increase over the 1980s. This growth was spurred by the adoption of higher yielding corn varieties in Bolivia and Peru. Despite this improvement, the region's grain yields remain at about two-thirds of world levels.

Nearly all of Sub-Saharan Africa's production growth was due to area expansion, as yield growth was negligible. The region's grain yields per hectare are the lowest in the world, measuring about one-third of world averages. Yields of corn—a staple crop for many countries in the region—have basically stagnated since the mid-1970s and currently equal about one-fourth of world levels.

Sub-Saharan Africa's reliance on area expansion for growth in output is unsustainable. Much of the land being brought into production at this point is of poor quality. Therefore, increases in production will need to come from higher yields.

In addition to inadequate production growth—on a per capita basis—short-term production shocks intensify the food security problems in many of these countries. Extreme weather events, though significant, were not the only cause of short-term production shocks. Political instability was also a contributing factor. Projected improvements in yields from technological advances may not be enough to counter repeated short-term shocks. Shocks to agricultural production are compounded by the lack of effective food safety net programs in Sub-Saharan Africa to ward off famine.

Annual grain production in 14 of the 70 countries studied here fell by more than half in 1 year at least once during the last two decades. In that time, 53 of the 70 countries suffered production shortfalls of at least 20 percent at least once during the last 20 years, while 17 experienced such shortfalls more than five times (fig. 2-3). Successive years of drought caused grain production in Southern Africa to drop 20 percent in 2001 and 14 percent in 2002.

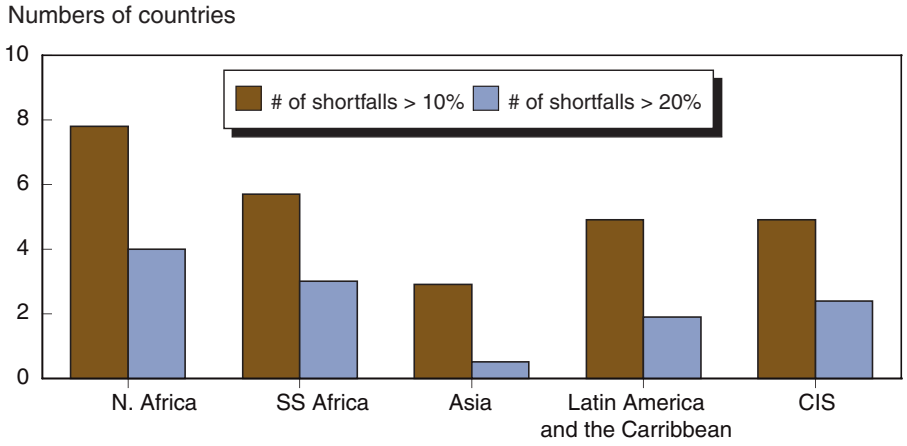
Factors Affecting Yields

Growth in agricultural production can result from extending the agricultural land base and/or intensifying production per unit of land. Given economic and environmental constraints on cropland expansion, however, the bulk of increased crop production will need to come from increased yields on existing cropland. Yields depend on the availability and quality of resources. In low-income, food-deficit countries, the dominant resources are land and labor. Inputs that require capital, such as fertilizer, machinery, and irrigation technology, are not widely used in these regions.

Purchased inputs and the use of new technologies can increase production efficiencies and resulting yields. The development and dissemination of

Figure 2-3

Production shortfalls from trend (1980-2000) are more frequent in Africa



Source: Economic Research Service, USDA.

technologies and practices that maximize yield potential for a particular area will depend on a country's ability to make needed investments and farmers' willingness and ability to adopt the provided technologies.

Farmers choose between technologies based on land characteristics such as soil quality and access to water, as well as personal characteristics like land tenure, income/wealth, and access to credit and information. The farmer's choice of practices, such as fertilizer application and residue management, depends on the time horizon. For example, practices generating high net returns today may not do so indefinitely if they cause land degradation. But practices that reduce land degradation and offer higher net returns in the long run may require initial investments that inhibit adoption.

In recent decades, about half of all gains in crop yields have been attributed to increased use of conventional inputs, especially fertilizer and irrigation water; the remainder was due to genetic improvements in seeds.

Fertilizer Use

FAO data and analysis indicate that increased fertilizer consumption accounted for one-third of the growth in world cereal production in the 1970s and 1980s. Growth in fertilizer consumption per hectare of cropland has been slowing, however, from a global average annual increase of 9 percent in the 1960s to an average annual decline of 0.1 percent in the 1990s. Growth in fertilizer use in developing countries is expected to exceed that of developed countries in the coming years. Developed countries are considered a mature fertilizer market. Also hindering growth in fertilizer use is the increasing awareness of potential environmental harm.

Developing countries' fertilizer consumption has increased rapidly during the last two decades. In 1980, these countries accounted for a third of global consumption. This share doubled to two-thirds by 2002. Among developing regions, per-hectare fertilizer consumption increased most rapidly in land-

scarce Asia and most slowly in Africa. Fertilizer consumption in Sub-Saharan Africa virtually stagnated during the 1990s. The region accounts for only 1 percent of global consumption. In many low-income countries, particularly in Sub-Saharan Africa and Latin America, almost all fertilizer is imported, and insufficient foreign exchange constrains availability. Fertilizer use is most productive on irrigated area or areas with sufficient moisture. Therefore, in regions suffering from or vulnerable to dry periods (Latin America or Sub-Saharan Africa), fertilizer use would not have the results that would be experienced in areas without similar adversities. Consequently, increased fertilizer use in those regions might be limited to irrigated areas or regions where rainfall is more predictable.

Changes in fertilizer use will depend partly on its potential to mitigate onsite land degradation (depletion of soil fertility) versus increased offsite degradation (impacts on water quality, for example).

Irrigation

FAO reports that grain yields in developing countries are more than twice as high in irrigated areas as in rainfed areas. Agriculture accounts for 70 percent of freshwater use worldwide and over 90 percent of withdrawals in low-income developing countries. Globally, irrigated area increased nearly 1.4 percent per year between 1980 and 2002, although the growth rate has declined over time. Growth in developing countries exceeded this rate, and currently more than a quarter of arable land area in developing countries is irrigated. It is estimated that about half of the grain production in developing countries is grown on irrigated land.

The highest growth in irrigated area in the developing world has occurred in Asia, particularly Bangladesh, Nepal, and Vietnam. In East and Southeast Asia, more than 28 percent of arable land is irrigated. In the Latin American and Caribbean countries, nearly 13 percent of arable land is irrigated. Irrigation is severely limited in the most nutritionally vulnerable region, Sub-Saharan Africa. The region accounts for less than 2 percent of the world's irrigated area. Less than 4 percent of its arable land is irrigated. In addition, expansion of irrigated land in the region is negligible—0.5 percent per year since 1990. This rate marks a significant slowdown from growth in the prior decade. Irrigation requires access to water as well as investment in equipment and maintenance—all factors that are elusive in most of Sub-Saharan Africa.

Population growth and the increasing cost of developing new sources of water will place increasing pressure on world water supplies in the coming decades. Even as demand for irrigation water increases, farmers face growing competition for water from urban and industrial users, as well as pressure to protect water's ecological functions. In addition, waterlogging and salinization of irrigated land threaten future crop yields in some areas.

The World Bank and others are reducing their investments in major irrigation projects, and concentrating more on improving water management at the local level in low-income countries. Improved water management not

only has a direct effect on crop growth, but can also increase the efficiency of other inputs. As mentioned, the principal factor limiting yield response to fertilizer use is the inadequate supply of water during the growing season.

Improved Seed Varieties

Genetic improvements to seeds that enhance input responsiveness, resistance to pests and diseases, and tolerance to other stresses have driven much of the gains in yields of late. By the 1990s, 90 percent of land in wheat in developing countries was in scientifically bred varieties, as was 74 percent of land in rice and 62 percent of land in corn. In developed countries, 100 percent of land in wheat, corn, and rice was in scientifically bred varieties by the 1990s (and probably even earlier). Gains from genetic improvements will continue, but likely at slower rates and increasing costs, particularly because gains in input responsiveness have been almost fully exploited. Moreover, while the use of hybrid seeds has raised yields considerably in some countries, their proliferation may not be possible in many developing countries where conditions are not amenable.

Despite these potential limitations, we examined the potential impact of higher yielding varieties on food security in a few Sub-Saharan African countries. This region is the most vulnerable to food shortages, but use of higher yielding varieties is limited largely due to financial constraints facing farmers. Using the Food Security Assessment model (see Appendix 1), we attempted to measure the impact of adopting these varieties by raising yields from their actual levels in 2004. We then examined the implications on food security by reviewing the resulting changes in the distribution gaps—the amount of food needed to raise consumption in each income group to the nutritional target. We chose Ethiopia, Tanzania, Madagascar, and Mali as the test cases because these four countries accounted for an estimated 40 percent of the Sub-Saharan distribution gap in 2004. In "Genetically Engineered Corn in South Africa: Implications for Food Security in the Region" (p. 35), the authors refer to a study performed in South Africa where farmers used GE corn and realized yield increases of roughly 10 percent. We assume a similar result for grains in the study countries, and the distribution gap subsequently declines 24 percent. We then went further and assumed yields to rise to the average of all developing countries. In this scenario, the gap is virtually eliminated—Madagascar is the only remaining country with a gap, and it is negligible. So, despite significant constraints to adopting these technologies, the benefits of doing so could be dramatic.

Prospects for Production Growth

Many developed and some developing countries are close to their maximum scientific and technical potential for growing crops. Therefore, maintaining current growth rates will be unlikely in these areas with today's technologies and practices. However, in many countries—particularly in Sub-Saharan Africa and Latin America—agricultural productivity can exceed that of historical levels. To do so, these countries must promote investment in agricultural research, technology education, and rural infrastructure.

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