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Agricultural Productivity: An Engine of Development

Agricultural productivity *measures the amount of agricultural output produced with a given level of inputs. Agricultural productivity can be defined and measured in a variety of ways, including the amount of a single output per unit of a single input (e.g., tons of wheat per hectare of land or per worker), or in terms of an index of multiple outputs divided by an index of multiple inputs (e.g., the value of all farm outputs divided by the value of all farm inputs).*

Science and Technology Contribute to Productivity

Technological advancement, broadly defined as any positive change in the way goods and services are produced, has been recognized by economists as a critical contributor to economic growth. Research is necessary to innovate, but product development and testing are needed before commercialization or transfer of technology can occur. Producers need good market and policy incentives to adopt new technologies, and the skills to use them effectively. These basic components of technology development and dissemination are the same in developed and developing countries.

R&D increases productivity

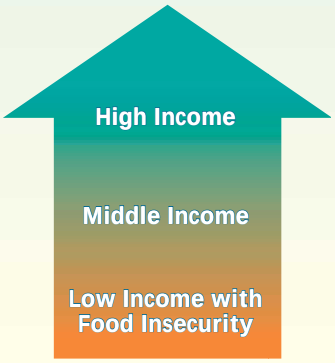
New technologies and innovative practices have been key factors in the economic development of high-income countries. Investments in agricultural research and development (R&D) by both the private and public sectors have resulted in a high level of productivity. The production of more agricultural goods using fewer inputs frees resources to be invested in other parts of a country's economy, thus increasing affluence. Productivity increases occurred because of innovations in machinery, pesticides, fertilizers, information technologies, and plant breeding. While there has been a focus on production improvements for

Research Priorites To Meet Consumers' Needs

Consumer demands depend in part on income level, and public and private research priorities change to meet those demands. To supply the products demanded in high-income countries, the private sector invests in research to develop value-added products that can be profitably traded. Public-sector agricultural research can develop technologies and practices used to ensure food safety and to lessen potential environmental impacts of production. If consumer demand is strong for products that meet food safety or environmental quality criteria, the private sector can provide these products profitably as well. In developing countries, the public sector may need to enhance its science and regulatory infrastructure to ensure a safe food supply and a protected environment.

To meet demands in middle-income countries, both public and private agricultural research programs focus on providing increased quantities of affordable sources of nutrition. There is less demand for value-added and processed products than in high-income countries.

In less-developed countries, demand for imported products is low. R&D efforts within many of these countries are not sufficient to substantially increase agricultural productivity, and opportunities for profitable private research investment are limited. The success of public research depends on financial resources and educational levels (human capital), as well as on natural resource endowments, adequate infrastructure, and political stability, among many factors. Due to constraints on many of these enabling factors, less developed countries often do not have the strong indigenous public research capacity needed to develop technologies suited to their needs.



Research Priorities Change

Private Research—focuses on varied, fresh, convenient foods.
Public Research—focuses on food safety and improved environmental quality.

Private and Public Research—focuses on high nutrition and increased production efficiency.

Public Research—focuses on productivity of local staple products.

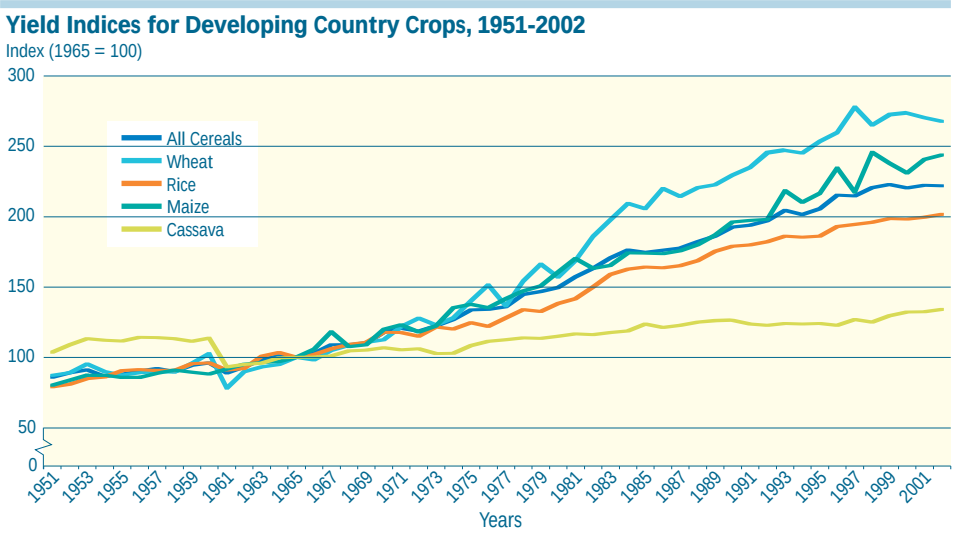
farmers, consumers also benefit from the increased production of basic commodities at low prices. Innovations in food storage, processing, packaging, transportation, and increasing shelf life resulted in a wide variety of high-quality products being available year round. Recent breakthroughs in information technology and life sciences have expanded opportunities to increase production efficiency and to provide consumers with the safe, affordable, nutritious products they demand.

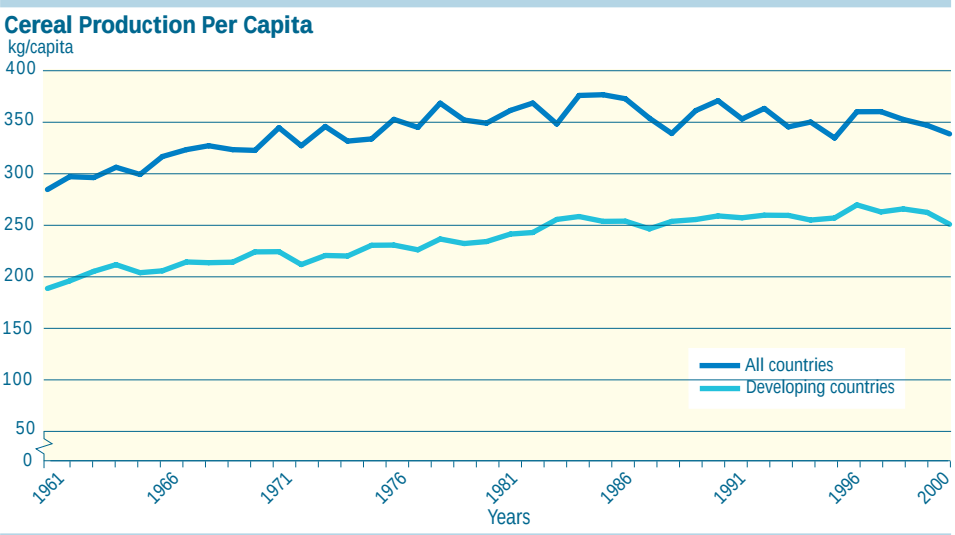
Consumers are increasingly concerned with the safety, variety, and nutritional value of food products. In addition, the public demands that agricultural production practices protect the environment and conserve natural resources. Some agricultural practices have had detrimental effects on human health and the environment. Public research efforts have developed technologies and practices that have reduced these negative effects, and it is that set of technologies from which countries choose when trying to achieve their sustainable agricultural goals.

The Green Revolution

The dramatic breakthrough in agricultural research in industrial countries, exemplified by yield gains and increases in agricultural productivity, took many years to reach some developing countries and bypassed others altogether. Before the 1960s, in developing countries, relatively little was invested in agricultural research, particularly for food crops. At that time, the Rockefeller and Ford Foundations helped establish an international agricultural research system to serve the research needs of developing countries.

The first efforts were in public research for rice, wheat, and maize. By the late 1960s, the development and spread of high-yielding varieties of these crops, combined with greater use of fertilizers and irrigation, led to notable increases in crop yields that greatly expanded the scope of the Green Revolution. This accomplishment reduced the incidence of famines, particularly in densely populated





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countries in Asia. High-yielding varieties were developed by philanthropic or public research institutions and then given away or sold at low prices.

Yield growth for various crops in developing regions has been substantial during the past three decades. For example, since 1965, wheat, rice, and maize yields in developing countries have more than doubled. The contributions made by agricultural R&D to increasing food production, however, extend beyond yield increases alone. One of the major contributions of rice genetic improvement has been the development of varieties that produce yields similar to those of older rice varieties, but in shorter periods of time and with less loss of grain. This has enabled double or even triple cropping in areas that previously produced only one or two crops per year. For other staple crops such as cassava, yield gains have been relatively modest.

The net result of this R&D-driven technological transformation has been an increase in per capita food production in developing countries taken in the aggregate. From 1960 to 2000, for example, developing countries' population grew by around 125 percent, while the production of cereal in these countries tripled. Over the same period, agricultural land in developing countries increased by only about 25 percent. Thus, increased yields per hectare, not the expansion of agricultural land, played the dominant role in expanding cereal production. In some regions, however, the expansion of agricultural land resulted in the loss of some ecological assets, but conservation efforts

Summary of nearly 400 studies of the economic rate of return to agricultural R&D

Region	Number of studies	Economic rate of return (median percent)
Asia	120	~ 55
Latin America	80	~ 40
Africa	44	~ 35
All developing	244	~ 50
Organization for Economic Cooperation and Development (OECD)	146	~ 45

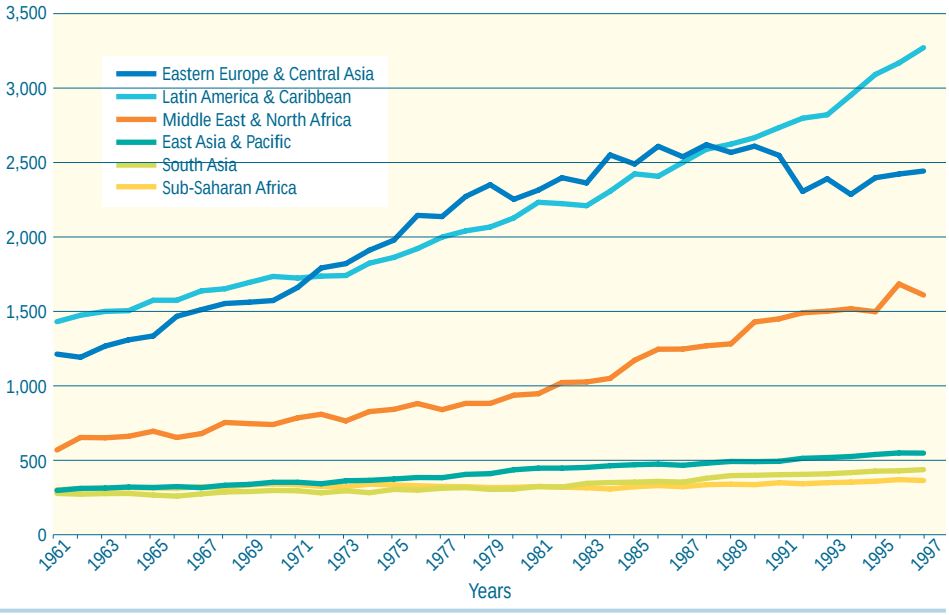
Source: R.E. Evenson; Handbook of Agricultural Economics

Not all countries have benefited from agricultural innovations.

Labor productivity in developed countries was $5,400 per worker in 1961 and $25,000 in 1997.

Labor Productivity

$ per worker



have been successful in slowing those losses in other areas. India was able to increase conservation efforts and actually expand its forests and woodlands by 21 percent between 1963 and 1999.

Economic studies have indicated that the rates of return to investment in agricultural R&D tend to be high in both developing and developed countries. Developing countries have made many impressive, scientifically based gains in food production over the past 40 years. However, these successes have not been universal.

Yield gains have been distributed unevenly among food crops that are important in developing countries. Much of the Green Revolution crop research resulted in advancements in wheat and rice production. Some maize/corn improvements were made that benefited part of Africa, but research did not focus on Africa's primary staple crops: yams, cassava, sorghum, and cowpeas. Though yields for root crops like cassava have risen slowly since the 1960s, the rate of increase in yield has been much lower for these crops than it has been for cereals.

Studies have shown that although small farmers lagged behind large farmers in adopting Green Revolution technologies, in many cases they eventually did benefit from the use of these innovations. In both developing and developed countries, the farmers who can absorb the risks associated with trying new agricultural technologies due to their access to credit or larger holdings often adopt first. Their success serves as a model for those farmers who were initially uncertain about the new technology.

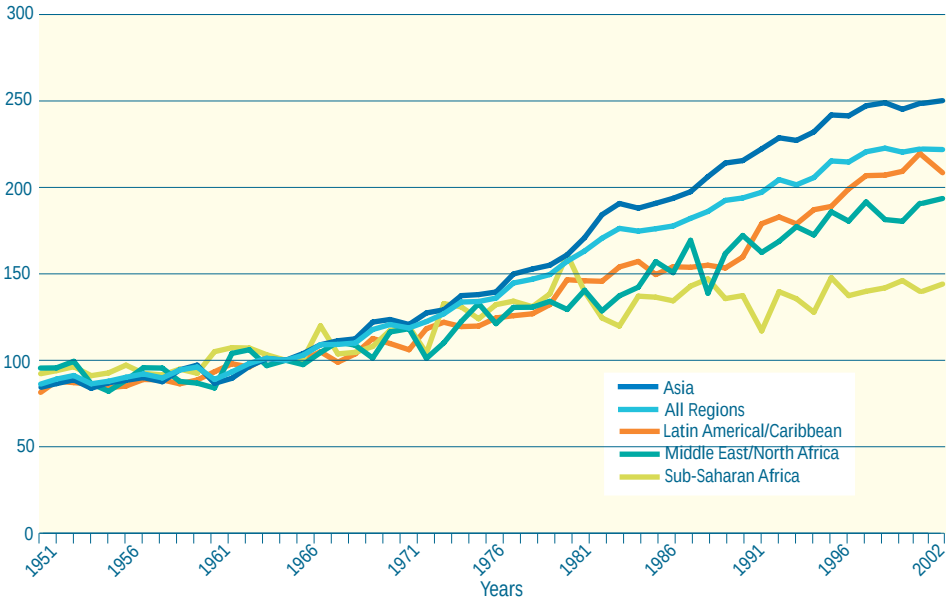
Despite the many benefits to developing countries that resulted from the Green Revolution, there were some negative environmental impacts. To effectively grow high-yielding crop varieties, fertilizers, pesticides, and water often were needed. Chemical residues were transported into waterways in tropical regions, and built up in soils in arid areas. Some chemicals leached into ground water. The use of synthetic pesticides had impacts on farm family health, and reduced the natural enemies of some targeted pests. These negative effects were experienced at the same time in developed countries, which led to research on technologies and practices to avoid the problems in the future.

Unmet Needs for Food Security and Income Growth

Many developing countries have a great need for increased productivity growth. Population growth rates in lower income countries are generally higher than in developed regions. If current trends continue, the world's population is expected to increase by 737 million people by 2011, and most of the growth will be in developing countries. Unfortunately, crop yields are often substantially lower in these developing regions. Even though world food production has been increasing faster than population growth, many people are undernourished in less developed regions. In Sub-Saharan Africa, 43 percent of the population is chronically undernourished, consuming less than the minimum recommended nutritional requirements. However, the greatest numbers of undernourished people live in Asia, which is the most highly populated region.

With high population and low productivity levels, many low-income countries are not able to produce enough food domestically to meet basic nutrition needs. Nor do they have adequate income to

Cereals Yield Indices for Developing Regions, 1951-2002



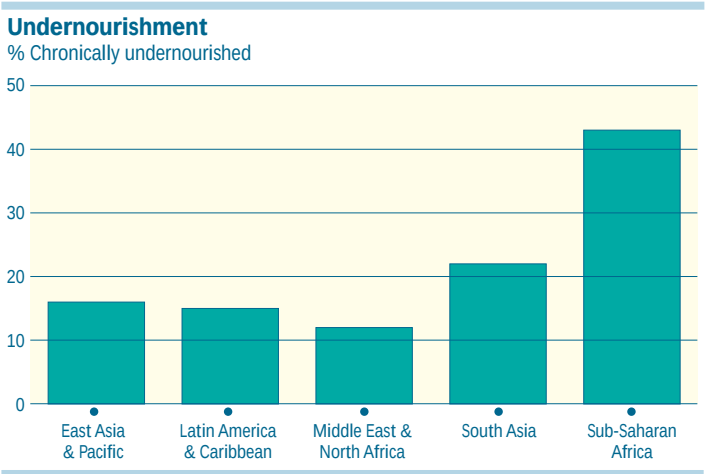
***Food security** is defined as access by all people at all times to sufficient food for active, healthy lives. As such, food security depends not only on how much food is available, but also on the access that people have to food–whether by purchasing it or by producing it themselves. Access depends in turn on economic variables such as food prices and household incomes, as well as on agricultural technology and the quantity and quality of natural resources.*

Given that 90 percent of the food consumed in many developing countries is produced locally, production increases and product diversification could improve the health and well-being of the poor.

import enough to eliminate these food gaps. Agricultural productivity in developing countries must grow more rapidly than it has in the past decade, both to meet increasing demands for food and to raise rural and urban incomes—which, in turn, will lead to the possibility of increased agricultural trade and earning foreign exchange. For example, since 1980, farm worker productivity rose by nearly 50 percent in Thailand, nearly doubled in China, and more than tripled in South Korea. These increases had significant effects on Asia's economies by stimulating growth, reducing poverty and malnutrition, and helping to keep food prices down. The development and adoption of new technologies will be necessary to increase both food supplies and access to food.

Food-insecure countries with low incomes, reliance on local staple crops, and limited trade opportunities have benefited less than other developing countries from R&D-based advances in food production. Many of the most significant advances in agricultural technology were made in developed countries where greater resources were devoted to agricultural R&D. Although food-insecure countries can be found in all major developing regions, they are particularly concentrated in Sub-Saharan Africa. In the lowest income countries, about one-third of food consumption comes from noncereal commodities such as cassava, for which there have been limited research investments and few technological breakthroughs. In much of Sub-Saharan Africa, per capita food production has declined in the last two decades, a period in which public sector investment in agricultural R&D stagnated in this region.

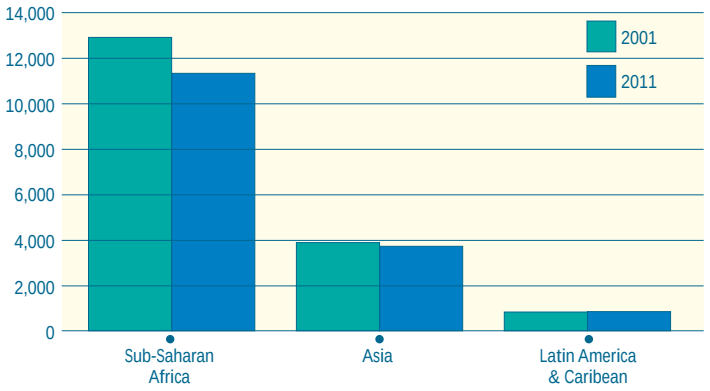
The World Bank estimates that 75 percent of the very poor, or nearly 1 billion people, live and work in rural areas and depend on agriculture for their livelihoods, either directly or indirectly. Given that 90 percent of the food consumed in many developing countries is produced locally, production increases and product diversification could improve the health and well-being of the poor. Food security is the foundation for social security.



Undernourishment is a severe problem in several regions.

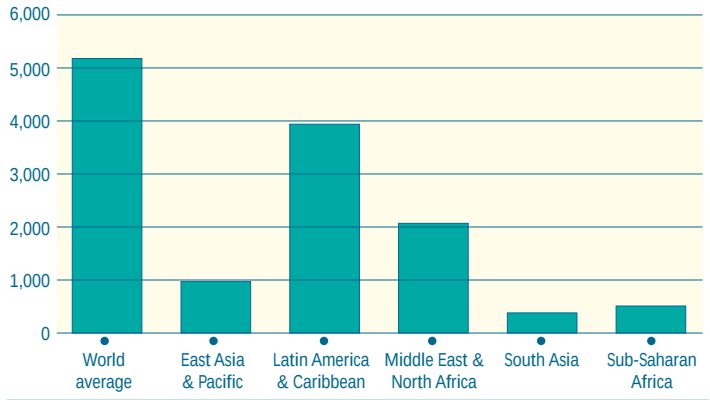
Food Needed To Achieve Food Security

Thousand tons



Per Capita Gross National Product

$/capita, 1997



World Population, 2001 Estimate (Total = 6.1 billion people)

Millions