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The Benefits of Fertilizer Use in Developing Countries

International Fertilizer Development Center

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Table of Contents

	Page
Introduction	1
Population Growth, Food Production, and Fertilizers	1
Population Growth	1
Food Production	1
Fertilizer Use and Food Production	2
Fertilizer Use and Agricultural Development	4
Fertilizer Use and Land Productivity	4
Fertilizer Use and the Green Revolution	4
Fertilizer Use and Returns to Irrigation Investments	5
Fertilizer Use and Farmers' Income	5
Fertilizer Use and Employment	5
Fertilizer Use and Foreign Exchange Earnings/Savings	6
Fertilizer Use and Sustainability of Agricultural Production	6
Fertilizer Use and Food Security	7
Fertilizer Use and Social Benefits	8
Fertilizer Use and Nonagricultural Benefits	9
Summary and Conclusions	9
References	10

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The Benefits of Fertilizer Use in Developing Countries

Introduction

Regardless of the measurements used to understand the social and economic well-being of developing countries in Africa, Asia, and Latin America, the contrast between those regions and the industrialized countries is perspicuous and unequivocal. The developing countries are poorer in per capita income, and per capita food production is often limited and fluctuating.

The high birth rates and declining mortality rates in developing countries have led to rapid population growth and increased the already intense pressure on natural resources, which are critical for building a sustainable basis of agriculture. The need to increase food production in the developing regions is as pressing today as two decades ago. Over one billion people cultivate land under conditions that provide low yields and little or no food security. The resulting starvation, malnutrition, and poverty are important sources of social and political instability in developing countries.

The purpose of this paper is to identify and discuss the economic and social benefits of fertilizer use to economic development and food security in the developing countries. In the following sections the benefits of fertilizer summarized in Figure 1 are discussed. First, aspects of population growth, food production, and fertilizer use that characterize developing countries are presented. In the second section the contributions of fertilizer use to various aspects and objectives of agricultural development such as land productivity, the Green Revolution, returns to irrigation investments, farmers' incomes,

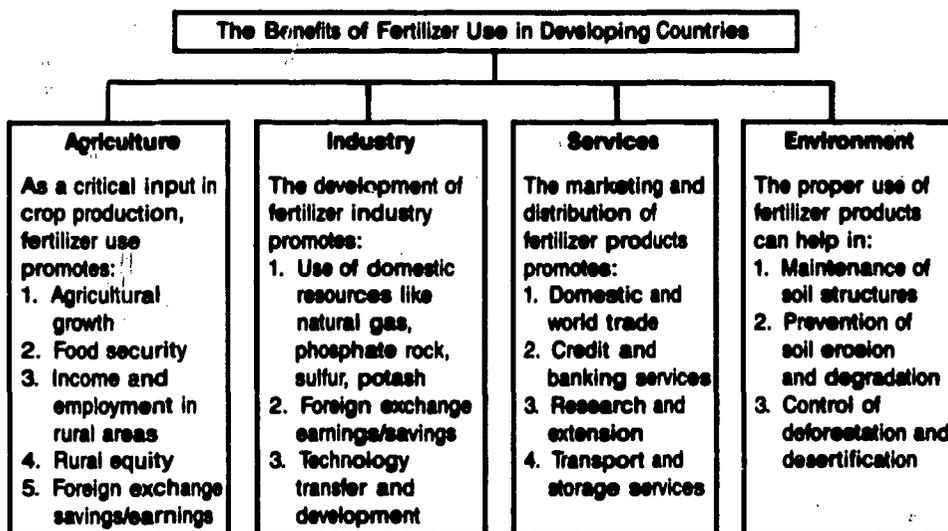


Figure 1. Summary Chart of the Benefits of Fertilizer Use in Developing Countries.

rural employment, foreign exchange savings, sustainability of agricultural production, and food security are discussed. The third section discusses the benefits of fertilizers outside the agricultural sector.

Population Growth, Food Production, and Fertilizers

Population Growth

The United Nations population projections indicate that world population will increase from 4.8 billion in 1985 to 6.1 billion in 2000 [11]. A little more than 90% of this increase is expected to occur in the developing countries. Thus, the population of all developing countries will increase from 3.6 billion in 1985 to 4.8 billion in 2000, an annual increase of 1.9%. This increase in population along with the expected increases in per capita income will make the demand for food and other agricultural products expand at

an annual rate of 3.1%. The experience of the last 25 years (1961-85) indicates that agricultural production can be increased to meet this expansion in demand provided proper policies and programs are adopted by both the developed and the developing countries [2,10].

Food Production

Worldwide production of cereals and root crops, the most important staple foods in developing countries, increased from 1,390 million tons in 1961-63 to 2,345 million tons in 1983-85, an annual increase of 2.4%. Of the total increase of 955 million tons, about two-thirds was in the developing countries. As food production increased at a higher annual rate in the developing countries (Table 1), the share of these countries in global food production increased from 46% in the early 1960s to 54% in the mid-1980s.

Because of higher growth in food production in the developing countries and increased imports,

Table 1. World Food Production, 1961-63 and 1983-85^a

	1961-63		1983-85		Annual Growth Rate
	Million Tons	%	Million Tons	%	
Developed countries	749	54	1,067	46	1.6
Developing countries	641	46	1,278	54	3.1

a. Includes cereals and root crops.

Source: Derived from data in FAO Production Yearbooks.

especially by the oil-rich countries, per capita daily consumption of food grains increased from 1,960 calories in 1961-63 to 2,420 calories in 1983-85, about 23% increase.

However, that increase was uneven among different regions and countries (Table 2). Overall, the value of world agricultural production increased at an annual rate of 2.5%, or 3.2% in the developing countries and 2% in the developed countries during the 1961-85 period.

This growth in agricultural production was a result of increases in harvested area and productivity (crop yields or crop output per hectare). FAO estimates indicate that about one-third of the increase in crop production was due to increases in harvested area and about two-thirds due to increases in crop yields. Notable among the crops whose yields increased were rice and wheat. During the 1969-71 to 1983-85 period, wheat yield increased by 70% and rice by 41%. Yields of other cereals such as maize, barley, millet, and sorghum also increased appreciably (Table 3).

Fertilizer Use and Food Production

Several factors such as improved crop varieties, expanded irrigation, better farm practices, and increased use of fertilizers contributed to what the World Commission on Environment and Development called the "phenomenal" increases in crop yields, but the increased use of fertilizers contributed the most to such increases [10].

Table 2. Food Availabilities for Direct Human Consumption, in Calories per Capita per Day.

	1961/63	1969/71	1979/81	1983/85
World	2,320	2,450	2,600	2,660
Developing Countries				
94 developing countries	1,960	2,110	2,320	2,420
93 developing countries (excluding China)	2,070	2,170	2,330	2,360
Africa (Sub-Saharan)	2,050	2,100	2,150	2,050
M. East/N. Africa	2,220	2,370	2,850	2,960
Asia	1,860	2,030	2,240	2,380
Asia (excluding China)	1,970	2,070	2,200	2,250
Latin America	2,380	2,520	2,680	2,700
Low income countries	1,870	2,010	2,180	2,310
Low income countries (excluding China)	2,000	2,050	2,100	2,130
Low income countries (excluding China and India)	1,950	2,080	2,090	2,090
Middle income countries	2,160	2,340	2,620	2,660
Developed Countries	3,090	3,260	3,370	3,370
North America	3,250	3,460	3,590	3,630
Western Europe	3,110	3,260	3,390	3,360
Other developed market economies	2,590	2,810	2,920	2,890
European centrally planned economies	3,160	3,330	3,410	3,410

Source: FAO: *Agriculture Toward 2000* (1987, page 27).

Table 3. Yields of Major Crops in Developing Countries.

Crops	1961-63	1982-84	Percent Change
	----- (tons/ha) -----		
Wheat	1.0	1.7	70
Rice (Paddy)	1.7	2.4	41
Maize	1.1	1.6	45
Barley	1.0	1.2	20
Millet	0.5	0.6	20
Sorghum	0.7	0.9	29
Cassava	7.7	9.2	19
Sugarcane	45.7	57.4	26
Soybeans	0.7	1.6	128
Groundnuts	0.8	0.9	13
Coffee	0.4	0.5	25
Cotton (Seed)	0.7	0.8	14

Source: FAO. *Agriculture Toward 2000* (1987, page 120)

Yield increases will continue to play an important role in meeting the growing demand for food and non-food products in the future. FAO estimates indicate that during the 1985-2000 period, yield increases will continue to be the source of two-thirds of the increase in agricultural output. There are, however, regional variations around these aggregate averages (Figure 2). Fertilizers will play a significant role in increasing crop yields for the following reasons: first, per hectare fertilizer use is still very low in many

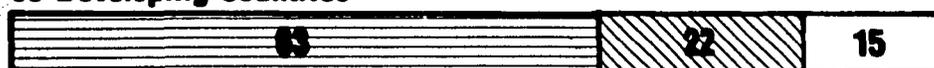
developing countries, especially in sub-Saharan Africa (Table 4), and second, the increased fertilizer use has played a leading role in bringing about rapid growth in global food production in the past. This is indicated by the following FAO observation:

A tremendous increase in fertilizer usage—a tenfold increase in developing countries and a doubling in developed market economies between 1961/63 and 1983/85—was possibly the most potent single factor in raising productivity [2].

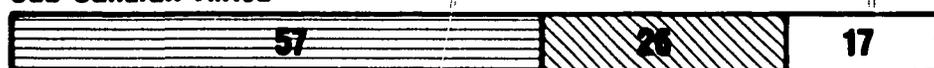
Fertilizer use will also play an important role in sustaining the resource base of agriculture by replenishing soil nutrients in the fragile soils of tropical forests and ranchlands that are likely to come under cultivation in Africa and Latin America.

The world food situation in the year 2000 is dependent on the actions taken in the 1980s. Progress in building a sustainable basis of agriculture in developing countries is

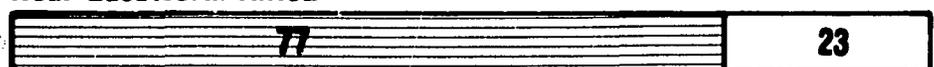
93 Developing Countries



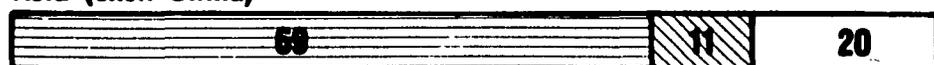
Sub-Saharan Africa



Near East/North Africa



Asia (excl. China)



Latin America



Source: FAO, *Agriculture Toward 2000*, (1987, p. 118).

Figure 2. Expected Percent Contributions of Yield, Land, and Crop Intensity to Crop Production Increases (1982-84 - 2000).

mediated by research, the finite limits of arable land, and the certain population growth toward the year 2000. There is a consensus that the arable land area available for the expansion of agriculture is severely limited. In Asia, 80% of the arable land area is now under cultivation. There is potential for expanding the area of cultivated land in Africa and Latin America; however, the soils in these areas are often poor in quality, and expanded cultivation may endanger ecologically fragile areas, such as tropical forests. Hence, increasing food production through intensive agriculture is indispensable to satisfy future food requirements of developing countries.

In order to achieve the required increases in crop yields and crop output, the FAO estimates that fertilizer use in developing countries (excluding China) should double during the 1985-2000 period. That is,

fertilizer use should increase at an annual rate of 4.7% from 25.8 million tons in 1984 to 56.0 million tons in 2000 [2]. Any shortfall in achieving these levels will result in slower growth in crop output and therefore less food for the rapidly increasing populations of developing countries.

The Director General of FAO, noting that aid should encourage the developing countries to rebuild their capacity to feed themselves, made these comments in reference to fertilizer use and intensive agriculture:

Fertilizers remain an invaluable tool in the protracted battle against hunger. A ton of fertilizer aid often translates into ten or more tons of grain. The surge in purchasing power it provides, through increased yields, is not appreciated enough [6].

Table 4. Per Hectare Fertilizer Use in Kilograms of Nutrient, 1985.

	kg/ha
By Regions	
World	87.1
Developed Market Economies	115.5
North America	85.1
Western Europe	226.1
Oceania	32.3
Others	164.6
Developing Market Economies	41.6
Africa	11.8
Near East	52.2
Far East	55.8
Latin America	41.4
Central Planned Economies	138.0
Europe	129.6
Asia	158.4
In Selected Developed Market Economies	
North America	
Canada	49.8
U.S.A.	93.7
Western Europe	
Denmark	241.8
France	300.9
Germany F.R.	427.3
Netherlands	783.3
Switzerland	436.2
U.K.	355.5
Oceania	
Australia	23.5
New Zealand	892.2
Others	
Japan	430.4
Israel	220.3
South Africa	66.7
In Selected Developing Market Economies	
Africa	
Angola	5.8
Burkina Faso	3.9
Cameroon	8.1
Ethiopia	4.7
Ghana	4.4
Cote d'Ivoire	11.8
Kenya	42.1
Malawi	11.4
Nigeria	10.8
Senegal	5.5
Sudan	7.5
Tanzania	7.6
Zambia	15.5
Latin America	
Brazil	42.5
Mexico	69.3
Colombia	64.3
Peru	20.1
Near East	
Turkey	53.8
Iran	60.9
Syria	40.5
Jordan	36.9
Far East	
Pakistan	73.7
Bangladesh	59.2
Indonesia	94.7
India	50.3
Philippines	35.8
Malaysia	116.5
In Selected Centrally Planned Countries	
Czechoslovakia	336.5
Hungary	252.7
Romania	146.0
U.S.S.R.	109.3
China	167.3

Source: FAO Fertilizer Yearbook, 1986.

The extensive contribution of fertilizer to world food production is also acknowledged in the following observation:

If fertilizers were no longer available to West European farmers, food production would decrease by an amount equivalent to the needs of 100 million people [1].

Fertilizer Use and Agricultural Development

Fertilizer Use and Land Productivity

The contribution of fertilizer to land productivity is indicated by the yield increase (response) brought about by the plant nutrients (nitrogen, potassium, and phosphorus) applied as fertilizers. Ratios of increased crop production per unit of nutrient applied vary with agroclimatic conditions, crops and varieties, application rates, and management practices. Experimental and farm data show that for cereals these ratios are between 3 and 25. Hence, average ratios of 5-10 are usually adopted to calculate the contribution of fertilizers to the production of cereals and land productivity.

As shown in Table 5, the increase in grain production between 1970-74 and 1980-84 in Africa, Asia, and Latin America was clearly related to the increased use of fertilizers. For that period, conservative estimates of increased grain production per unit of nutrient applied, calculated by assuming that the total increase in fertilizer use was applied to grain production, were 5.4, 10.4, and 7.4

Table 5. Increase in Average Grain Production and Fertilizer Use, by Region, Between 1970-74 and 1980-84.

Region	Grain Production		Fertilizer Use		Ratio of Increased Grain Production Per Unit of Nutrient Applied ^a
	Total Increase (million mt)	Share of World Increase (%)	Total Nutrient Increase (million mt)	Share of World Increase (%)	
Africa	8.2	2	1.5	3	5.4
Asia	200.3	55	19.2	45	10.4
Latin America	23.9	7	3.2	8	7.4
Total	232.4	64	23.9	56	9.7

a. Calculated by assuming that the total fertilizer increase was used only in grain production. Hence, these ratios should be considered as conservative estimates of the increased grain production per unit of nutrient applied.

Sources: U.S. Department of Agriculture, Economic Research Service, World Indices of Agricultural and Food Production 1950-85 (unpublished printout) (Washington, D.C., 1986); U.N. Food and Agriculture Organization, Fertilizer Yearbooks (Rome: 1982 and 1984).

Table 6. Contribution of Fertilizer to Agricultural Production Expressed in Cereal Production Equivalents, 1985.

	Total Nutrient Consumption (N+P ₂ O ₅ +K ₂ O) (million mt)	Increased Production per Unit of Nutrient	Increased Production Due to Fertilizer, in Cereal Equivalents (million mt)
Africa	3.44	5	17.2
Asia	40.69	10	406.9
Latin America	7.38	7	51.6
Total	51.51		475.7

Source: Derived from data in FAO Production and Fertilizer Yearbooks.

in Africa, Asia, and Latin America, respectively. On the basis of these ratios and amounts of fertilizers used, the estimated contribution of fertilizers to agricultural production in Africa, Asia, and Latin America represented the equivalent of 475 million tons of cereal in 1985 (Table 6), which is sufficient to provide food for several hundred million people for a year.

During the last four decades, the impact of fertilizers on the productivity of land and other inputs has been enhanced by the development and adoption of high-yielding varieties (HYV), which are more responsive to fertilizers. The increased productivity of land associated with the use of fertilizers and HYV of crops such as rice, wheat, maize, and sorghum has significantly increased the economic returns to in-

vestments in soil conservation and irrigation. Thus, the use of fertilizers has facilitated investments in soil conservation measures that enhance the preservation of the environment and has also improved the incomes of rural populations in developing countries.

Fertilizer Use and the Green Revolution

The Green Revolution continues to be recognized as the greatest achievement of international agriculture in the last two decades. The high-yielding varieties of wheat and rice, complemented with fertilizers, have dramatically transformed the lives of hundreds of millions of people in the developing countries.

The impressive increases in food production in Asia and, to a lesser

extent in Latin America during the last two decades, have been due to the development and adoption of Green Revolution technologies. The adoption of improved varieties of rice, wheat, maize, and sorghum, which are highly responsive to fertilizers, has been the main source of the tremendous expansion in food production. Such expansion, however, would not have been possible without the impressive increase in fertilizer use and the development of fertilizer products and management practices appropriate to the requirements of the new varieties. The response of crop yields to fertilizers in the case of improved varieties is often 50%-100% greater than the response of traditional varieties. Thus, crop yields are significantly increased as a result of using improved varieties and fertilizers. However, if fertilizers are not applied, yields of improved varieties are usually equal to or lower than those of traditional varieties. The Green Revolution, which helped developing countries increase food production, was sparked by HYV and fueled by fertilizer.

Fertilizer Use and Returns to Irrigation Investments

Of the approximately 200 million ha of irrigated land in the world, about 75% is in developing countries [5]. During the past 20 years irrigation has expanded about 3% per year. The United Nations has recognized that continued expansion of irrigated land and the associated use of fertilizer are crucial for meeting future food and fiber needs in the developing countries.

During the past 20 years the joint benefits of improved varieties, fertilizers, and irrigation in developing countries have been extraordinary. The yields from irrigated crop areas are frequently two or more times

greater than on nonirrigated land. However, such increments in yields reflect the joint benefits of irrigation and fertilizers and, often, those associated with the use of improved varieties. Although it is difficult to separate the benefits of each of these important sources of agricultural production, it must be recognized that the benefits of irrigation cannot be fully realized without the use of fertilizers. A number of irrigation investments in developing countries would not have been economically feasible without fertilizers.

The cost of irrigation varies with the type of system that is selected. The construction of irrigation tubewell systems may cost a few hundred dollars per hectare, while more sophisticated systems usually cost several thousand dollars per hectare [8]. An average increase of approximately 4 tons of grain per hectare, which is frequently obtained as a result of irrigation and fertilizer use, provides the necessary economic return to the investment in irrigation and additional profits to farmers. However, increments in grain production due to irrigation without fertilizer are usually insufficient to provide adequate economic returns on investment. The requirement for fertilizer to economically justify irrigation investments in developing countries is enhanced as more costly irrigation projects are constructed.

There is great potential in developing countries for increasing food production through improved use of irrigation and fertilizers. The International Irrigation Management Institute has suggested that the irrigated areas in developing countries are producing at far less than their potential and that most of the benefits of irrigation have occurred as a result of the magnitude of irrigation investments rather than the efficiency and productivity of systems [8].

Fertilizer Use and Farmers' Income

It is well documented that the use of fertilizer benefits farmers in several ways. First, it directly benefits them by increasing the productivities of land and family labor and, thereby, profits. Second, it expands the employment of farm labor and other inputs associated with fertilizer use. Third, the additional agricultural output due to fertilizer use increases the supply of agricultural products and lowers the prices of those products to consumers. Because farmers in developing countries are both producers and consumers of agricultural products, and frequently farm laborers, the benefits of fertilizer use accrue to them in these different ways. Thus, the use of fertilizers has both a direct and indirect impact on the incomes of farmers in developing countries.

Fertilizer value:cost ratios of 2-4, which are frequently observed under farmers' conditions in developing countries, imply that \$100 worth of fertilizer brings about \$100-\$300 of added profits to farmers. A farm survey study conducted in Bangladesh by the International Fertilizer Development Center (IFDC) [3] showed that, despite low levels of fertilizer use in some regions of the country, in 1979/80 farmers' incomes were increased by \$25 per acre of cropland as a result of fertilizer use. That study also indicated that on the average \$100 worth of applied fertilizers increased the incomes of farmers by about \$200 in the form of added profits and by \$40 in the form of added wages.

Fertilizer Use and Employment

Low income, underemployment, or lack of employment are important sources of social and political instability in developing countries. The general economic and social

well-being of the population of any country is dependent on the creation of employment opportunities that enable people to support themselves and provide sustenance to their families.

It is clearly evident that, for millions of families in the developing countries, the use of fertilizers generates employment opportunities in (a) activities related to the production, imports/exports, and marketing of fertilizers and (b) additional work on the farm itself.

The farm survey study conducted in Bangladesh by IFDC [3] showed that in 1979/80 fertilizer use resulted in the additional employment of farm labor at a rate of 10 workdays per acre of cropland and that \$100 worth of applied fertilizer increased employment of farm labor by 45 workdays. Thus, by extrapolation, the 840,000 tons of fertilizer consumed in Bangladesh in 1979/80 provided employment for the equivalent of approximately 540,000 farm laborers on a full-time basis.

Fertilizer Use and Foreign Exchange Earnings/Savings

In recent years the scarcity of foreign exchange in developing countries has been aggravated by the increasing burden of the heavy foreign debt that most countries in Latin America and Africa and some in Asia have accumulated. In order to alleviate this crisis, several countries have established policies to save scarce foreign exchange and possibly earn additional foreign exchange. The use of fertilizers affords developing countries an opportunity to earn foreign exchange when the increased production of agricultural products is exported or to save foreign exchange when such production reduces imports.

The increased use of fertilizers by food-deficit countries has reduced

imports and provided important savings of foreign exchange. Fertilizer value:cost ratios of 2-4 observed under farmers' conditions in developing countries imply that \$100 worth of fertilizer results in \$200-\$400 worth of added grain production. Hence, even if all fertilizers are imported, food-deficit countries are saving at least \$100-\$300 of foreign exchange for each \$100 worth of fertilizer used in grain production. Savings of foreign exchange associated with the use of fertilizers are usually greater than these figures indicate because (a) farm-gate prices include marketing costs (transport, storage, handling) incurred in domestic currencies and (b) some fertilizers are produced in these countries with varying levels of imported components.

For instance, in 1979/80 a total of 840,000 tons of fertilizer was consumed in Bangladesh, where farmers obtained average fertilizer value:cost ratios of 3.0 [3]. This represented foreign exchange savings of more than \$240 million in that year. The impact of fertilizer use in Bangladesh on foreign exchange savings is enhanced by the fact that the costs of transportation and distribution are important components of fertilizer prices and because a portion of the total amount of fertilizers consumed are actually produced in Bangladesh. In general, fertilizer imports are 2-3 times less expensive in foreign exchange than the equivalent importation of food replaced through increased production.

Fertilizer Use and Sustainability of Agricultural Production

Proper use and management of fertilizers are needed to increase land productivity and ensure the long-term sustainability of agricultural production. Although the inappropri-

ate use of some fertilizers or management practices can lead to the loss of soil fertility and environmental degradation, these cases seldom occur and are mostly the result of poor recommendations or policies. There is overwhelming evidence, however, about the contribution of fertilizers to increased agricultural production on a sustainable basis. A case in point is the development of U.S. agriculture where the intensive use of fertilizers with proper management and soil conservation practices has allowed sustainable yields over a period of more than 40 years. Additionally, fertilizers are recognized as a means to control soil erosion and environmental degradation.

The proper use of fertilizers in conjunction with good crop management techniques aids in erosion control by protecting surface soil through increasing the canopy cover, providing more crop residues, and improving the root system. Soil fertility and yield sustainability are simultaneously improved through the positive effects of fertilizers on soil nutrient levels and on the organic matter status of the soil. Data from the experiments conducted by IFDC in Latin America and Africa show that the direct application of ground phosphate rock on acid soils increased crop yields over several years and improved soil fertility. Similar results were also obtained with applications of lime. Several other studies [7] have illustrated the complementary effect of fertilizers with organic manures and composts in crop production. Fertilizer use enhances the contribution of legume-based crop rotations and/or organic manures and composts in increasing and sustaining crop production. In order to increase yields on a sustainable basis, the best results are obtained by combining organic manures or composts with fertilizers.

Given the widespread use of improved varieties in major wheat and rice-growing regions of the developing world, an important and continuous challenge is to sustain higher yields. Maintaining stable yields at high levels can be a complex task involving "maintenance research" in plant breeding, crop rotations and management, and fertilizer use technologies. National and international research organizations are giving a high priority to defending the gains already achieved. The sustainability of yields of improved varieties at high levels cannot be achieved without proper use of fertilizers. To quote FAO on this issue:

Attempts to increase productivity without adding nutrients to the soil will ultimately fail, especially when soils are already on the verge of degradation. Technologies that use minimum inputs are unlikely either to increase yields significantly or to prevent further degradation in adverse seasons. Therefore, technologies of the future must continue to use fertilizers or relatively large dressings of organic manure in order to restore soil structure and fertility [2].

Fertilizer Use and Food Security

Today, despite mounting food surpluses worldwide, hunger and malnutrition still exist. An estimated 730 million people suffer from hunger and malnutrition in the developing countries [9], although the world stocks of cereals, mostly in North America and Western Europe, were at an all-time high of 418 million tons in 1987. However, these stocks of cereals are subject to fluctuation as demonstrated by the reduction in 1988 caused by adverse weather in

the United States, India, and other parts of the world.

That paradox is caused by several factors. First, most of the food surpluses are in the developed countries while hunger and malnutrition plague the developing countries in Africa, Asia, and Latin America. Thus, there is a geographical imbalance of supply and demand. Second, the developing countries, where hunger and malnutrition prevail, have limited capacity to import food because of their debt crises and foreign exchange shortages. Third, even in those countries with the capacity to import food grains, poverty prevents many people from buying the necessary food to maintain healthy and productive lives.

One approach often used to alleviate the situation of food abundance on the one hand and hunger and malnutrition on the other is through the provision of emergency food aid. But emergency food aid is a precarious and ineffective way to provide food security to the food-deficit countries because (a) it is induced by surplus and therefore is unstable and unpredictable, (b) it creates a burden on the taxpayers of the donor countries, and (c) particularly important, it discourages production and reduces income and employment opportunities in the recipient countries.

Another approach is to increase the import capacity of the food-deficit countries by developing their export potential. Although there is some scope for expanding the export potential of the developing countries, the foreign exchange needs of these countries outweigh their potential earnings. Moreover, even if these countries have enough foreign exchange to import food grains, they cannot supply food to all in need because imports of food grains do not provide the employment and income that are needed by many people to purchase food, especially for those in

the rural areas. Thus, when the countries with untapped agricultural potential import food grains, their agricultural and rural populations are deprived of opportunities for employment and income. Then it can be said that those countries import unemployment [10].

A third and a more effective approach in resolving the paradox of food surplus in some countries and hunger and malnutrition in others is to increase production in food-deficit countries. Compared with the emergency food aid and food imports, this approach has at least three advantages. First, because food is produced where it is needed, time and resources are saved in transporting food from one country or region to another. Secondly, it provides greater social and political stability because of increased employment and adequate food supply. Finally, it helps the developed countries preserve natural resources and the environment by reducing areas cultivated with foodcrops and/or the amount of fertilizers and pesticides, which are more intensively used in these countries. Because of low levels of fertilizer use in the developing countries (Table 4), an increase in food production through the increased use of fertilizers poses no serious problem to the environment.

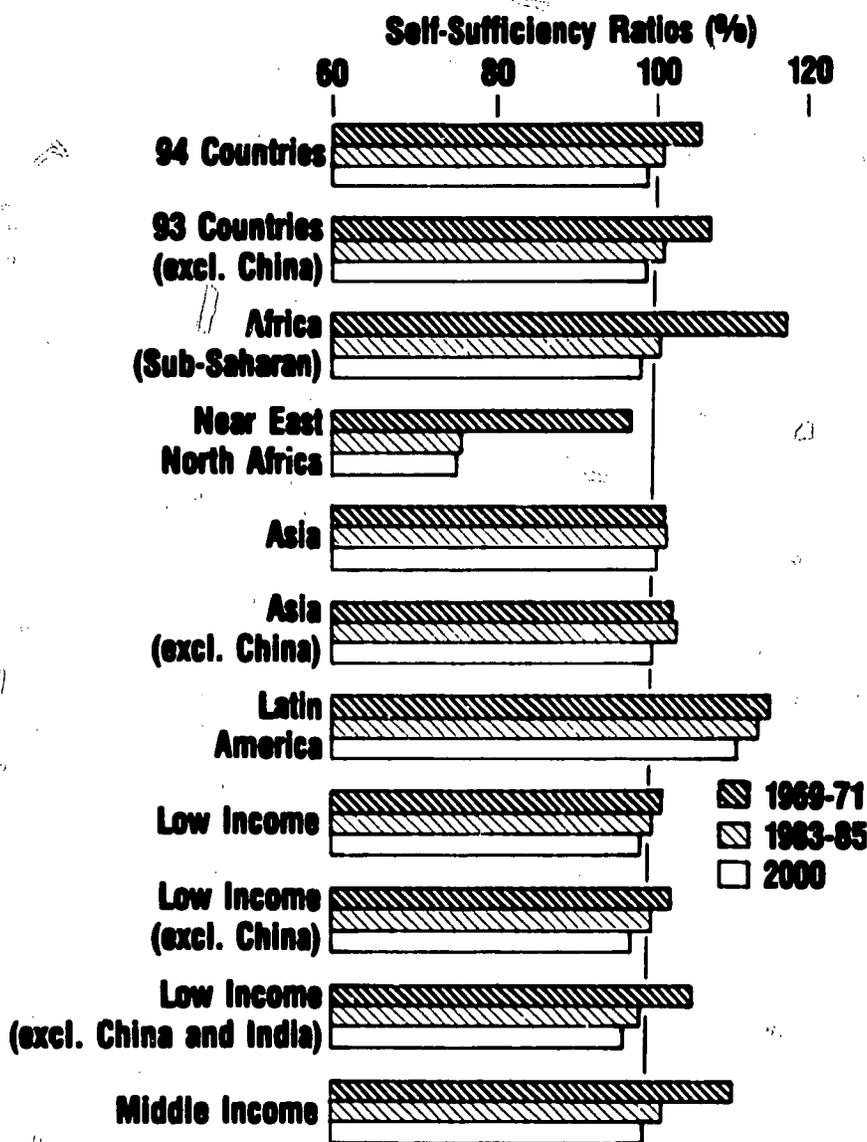
In order to shift the focus of food production from surplus to deficit countries, several changes in policies and programs related to agriculture and rural development are required. For example, investment in rural infrastructure and manpower should be provided; irrigation development and the use of improved crop varieties should be promoted; fertilizer use should be increased; and incentive prices for farm products should be provided. Of all these factors, one that can significantly contribute to the increase in food production in the short and long run is the

increase in fertilizer use. As indicated above, a ton of fertilizer nutrients can add 5 to 10 tons of food grains depending on agroecological conditions.

The contribution of fertilizers to food security is very well illustrated by the experience of India. In 1965/66, India produced about 72 million tons of food grains and imported about 10 million tons. In 1985/86, India produced about 150 million tons of food grains and had about 30 million tons of stocks. Food production was nearly doubled in 20 years through the widespread use of improved crop varieties, expanded irrigation, and accelerated fertilizer use. During the last 20 years (1966-86), fertilizer use in India increased from 785,000 tons in 1965/66 to 8,737,000 tons in 1985/86, an elevenfold increase.

Not only in India, but also in Indonesia and the Philippines, the increased use of fertilizers has contributed significantly to increased food security by promoting domestic food production. Both countries were rice importers in the 1970s but are now self-sufficient. Because of the low domestic cost of food production, these countries have achieved national food security at less than half the cost of imports.

While the accelerated growth in fertilizer use helped India, Indonesia, and the Philippines achieve food self-sufficiency and thereby food security, a slow growth in fertilizer use relative to population growth in sub-Saharan Africa has contributed to transforming sub-Saharan Africa from a food-surplus region in the late 1960s to a food-deficit one in the mid-1980s (Figure 3). Increased food security for sub-Saharan Africa requires changes in policies and programs in the agricultural sector coupled with substantial increases in fertilizer use.



Source: FAO, *Agriculture Toward 2000* (1987, p. 77).

Figure 3. Self-Sufficiency Ratios, Total Agriculture, 1969-71, 1983-85, and 2000.

Fertilizer Use and Social Benefits

In addition to the social benefits that are a result of the increased production, employment, and income associated with the use of fertilizers, the introduction and diffusion of fertilizer use among farmers of developing countries promote communication skills, education, and social integration.

The introduction and use of fertilizers provide a bridge for contact and interaction among farmers, ex-

tension workers, fertilizer dealers, and intermediaries in the marketing of agricultural output. Communication skills and education are enhanced through the teaching and learning process that occurs as a consequence of the marketing of fertilizers, use of fertilizers by farmers, and marketing of increased agricultural output.

The increased need for labor associated with the use of fertilizers enhances social integration at the family and village levels. Recent

evidence from West Africa indicates that farmers who use fertilizers provide employment to a large number of family members and relatives, and the increased production is shared in a cooperative manner that promotes family integration [4]. Social integration at the village level is promoted through the informal sharing and marketing of increased agricultural output among the village households.

Fertilizer use promotes the shifting of farmers from subsistence agriculture towards more productive market-oriented agriculture. The introduction and use of fertilizers provide a linkage between urban and rural areas in developing countries. That linkage makes an important contribution to the integration of rural areas into the life of national commerce, alleviates rural isolation, and promotes the diffusion of modern agricultural technology.

An important but intangible benefit of fertilizer use is the sense of achievement and satisfaction that farmers experience when food production is increased and the additional income is used for gifts, rituals, weddings, and the purchase of highly valued consumer goods, which further enhance social integration.

Fertilizer Use and Nonagricultural Benefits

In addition to providing substantial gains in crop output, food security, foreign exchange savings/earnings, income and employment, especially in rural areas, and in sustaining the resource base of agriculture, fertilizer use also creates several beneficial effects outside the agricultural sector.

First, because fertilizers are not produced on farms, their use at the farm level involves marketing and distribution of fertilizer products from the sources of supply (factories or ports or both) to the farm gate. Such

marketing and distribution activities generate income and employment opportunities for many.

Second, because not all of the countries have the resources to produce the required quantities of fertilizer products, fertilizer use promotes trade between different regions and countries. In 1985/86, world trade in fertilizer products amounted to more than 100 million tons. This exchange of products among countries promotes income and employment and helps in spreading the benefits of new production technologies.

Third, in those countries where raw materials are available, development of the fertilizer industry promotes the economic use of such resources and promotes import substitution or exports. For instance, India, Indonesia, China, and Nigeria have used natural gas reserves to develop their domestic fertilizer industries and thereby save foreign exchange used in importing fertilizers and to promote industrial development and employment.

An estimate of foreign exchange savings resulting from increased domestic production of fertilizer products is provided by the experience of India. India's fertilizer production increased sixteenfold from 357,000 nutrient tons in 1965/66 to 5,753,000 nutrient tons in 1985/86. If the production of India had been unchanged during the last 20 years, the foreign exchange cost of importing these additional 5.4 million tons of nutrients would have been about \$1.5 billion at the prevailing average world prices, which would have represented about 15% of the total export earnings of India. Many developing countries have indigenous resources to produce fertilizers; by developing these resources and increasing their use, these countries can significantly increase their foreign exchange earnings.

Summary and Conclusions

The various social and economic benefits of fertilizer use in the developing countries can be summarized as follows:

1. In feeding the growing population and in providing greater food security in the developing countries, fertilizers have played a leading role in the past and will continue to do so in the future for three main reasons. First, limited scope exists for the expansion of agricultural areas in many developing countries; second, even the areas likely to be brought under cultivation will need organic and inorganic fertilizers to maintain their yield potential because the soils of most of these areas are fragile in nature; and third, new crop technologies (improved varieties) are fertilizer intensive, and without fertilizer use, their yield potentials are lower than those of traditional varieties.
2. The increased use of fertilizers has played an important role in providing income and employment opportunities in rural areas and in saving and earning foreign exchange at the national level. These micro- and macroeconomic contributions of fertilizer use are likely to remain significant in the future as well because the incidence of poverty and unemployment is still very high in the rural areas of many low-income countries and the debt crises and foreign exchange shortages plague several developing countries.
3. Growth in fertilizer use is instrumental in promoting industrial and technical development at the country level and trade and technology transfer at the global level. Further growth in fertilizer use will help many developing countries to develop their raw

materials (phosphate rock, coal, natural gas, etc.) for domestic use and exports.

4. The introduction and use of fertilizers enhance communication skills and education as well as social integration. Fertilizer use promotes the integration of farmers and villages into the mainstream of the national economy.
5. Compared with the fertilizer use in developed countries of North America and Western Europe, fertilizer use per hectare of arable land in many developing countries is very low. For example, in 1984 per hectare fertilizer use in kilograms of nutrients in Brazil, India, and Nigeria was 43, 50, and 11, respectively, as compared with 94 in the United States, 301 in France, and 436 in Switzerland. Because of such low use levels, these countries are not expected to experience serious environmental problems associated with fertilizer use, which are believed to be experienced by the developed countries.
6. Deforestation, desertification, and soil erosion are serious environmental problems experienced by many developing countries, especially in Africa and Latin America. Increased fertilizer use combined with other complementary inputs can help in solving these problems by raising the productivity of cultivable land and thereby reducing pressures on marginal lands susceptible to desertification and soil erosion. Likewise, it can also help in protecting forest land because the increased production from cultivable land will lessen compulsions to clear forest land for cultivation.
7. The elimination or even the reduction of fertilizer use in developing countries will result not only in the starvation and mal-

nutrition of millions but also in an increased degradation of the environment through deforestation, soil erosion, and desertification, as has occurred in Africa in recent years. In the vast majority of agricultural areas of developing countries, the certain benefits of fertilizer use to the environment significantly outweigh any of the possible but uncertain detrimental effects.

References

1. Centre d'Étude de l'Azote, International Fertilizer Industry Association, Limited, and International Potash Institute. 1983. *Handbook on Environmental Aspects of Fertilizer Use*.
2. Food and Agriculture Organization (FAO) of the United Nations. 1987. *Agriculture: Toward 2000*, Economic and Social Development Series, Rome, Italy.
3. International Fertilizer Development Center (IFDC). 1984. "Agricultural Production, Fertilizer Use, and Equity Considerations: Results and Analysis of Farm Survey Data, 1980-82, Bangladesh" Muscle Shoals, Alabama.
4. Thompson, T. P., and C. A. Baanante. 1988. "A Socioeconomic Study of Farm-Level Constraints to Fertilizer Use in Western Niger," IFDC Paper Series P-6, IFDC, Muscle Shoals, Alabama, U.S.A.
5. Murdoch, W. W. 1980. *The Poverty of Nations: The Political Economy of Hunger and Population*, The Johns Hopkins University Press, Baltimore, Maryland.
6. Opening Address to the Session of the United Nations Food and Agricultural Commission on Fertilizers, February 1985.
7. Sedago, M. 1985. "Contribution à la Valorisation des Résidus Culturels en Sol Ferrugineux et Sous Climat Semi-Aride," Quoted in Herbert W. Ohm and Joseph G. Nagy (eds.), *Appropriate Technologies for Farmers in Semi-Arid West Africa*, Purdue University, West Lafayette, Indiana.
8. The International Irrigation Management Institute. 1988. "The Strategy of the International Irrigation Management Institute," Digana Village, Kandy, Sri Lanka, September.
9. The World Bank. 1986. *Poverty and Hunger: Issues and Options for Food Security in Developing Countries*, Washington, D.C.
10. The World Commission on Environment and Development. 1987. *Our Common Future*, Oxford University Press, New York, New York.
11. United Nations Educational, Scientific, and Cultural Organization. 1987. *Statistical Yearbook* (Paris, France).