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POLICY ENVIRONMENT CONDUCIVE TO THE GROWTH OF THE FERTILIZER INDUSTRY IN THE DEVELOPING COUNTRIES

Discussion paper

Prepared by

Pratap Narayan*

and

B. L. Bumb**

*Fertilizer Association of India (FAI), New Delhi.
**International Fertilizer Development Center (IFDC), Muscle Shoals, Alabama.

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Explanatory notes

The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO.

Unless indicated otherwise, all fertilizer quantities are expressed in nutrient tonnes; tonnes are metric tons.

DAP	diammonium phosphate
FADINAP	Fertilizer Advisory, Development and Information Network for Asia and the Pacific
FAI	Fertilizer Association of India
FAO	Food and Agriculture Organization of the United Nations
FPDD	Fertilizer Procurement and Distribution Division (Nigeria)
ICS	Industries chimiques du Sénégal
IFDC	International Fertilizer Development Center
IFFCO	Indian Farmers Fertilizer Cooperative Limited (India)
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
MAP	monoammonium phosphate
MMTC	Minerals and Metals Trading Corporation (India)
MOP	muriate of potash
NPK	nitrogen, phosphate and potash complex fertilizer products
PAPR-PA	partially acidulated phosphate rock - phosphoric-acid-based
PAPR-SA	partially acidulated phosphate rock - sulphuric-acid-based
PUSRI	P. T. Pupuk Sriwidjaja (Indonesia)
RPS	retention price scheme
Rs	Indian rupees
SOEs	State-owned enterprises
SSP	single superphosphate
TSP	triple superphosphate
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organization
WRI	World Resources Institute

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Introduction

The last three decades have seen rapid and historically unprecedented growth in population at the global level. The world population increased from 3.0 billion in 1960 to 5.5 billion in 1993 and is projected to reach 8.5 billion in 2025 (figure I). The world must plan, therefore, to feed an additional 3 billion persons in the next three decades, over 90 per cent of them in the developing countries of Africa, Asia and Latin America. The world must also plan to provide fibre, fuel and other necessities for a decent human life.

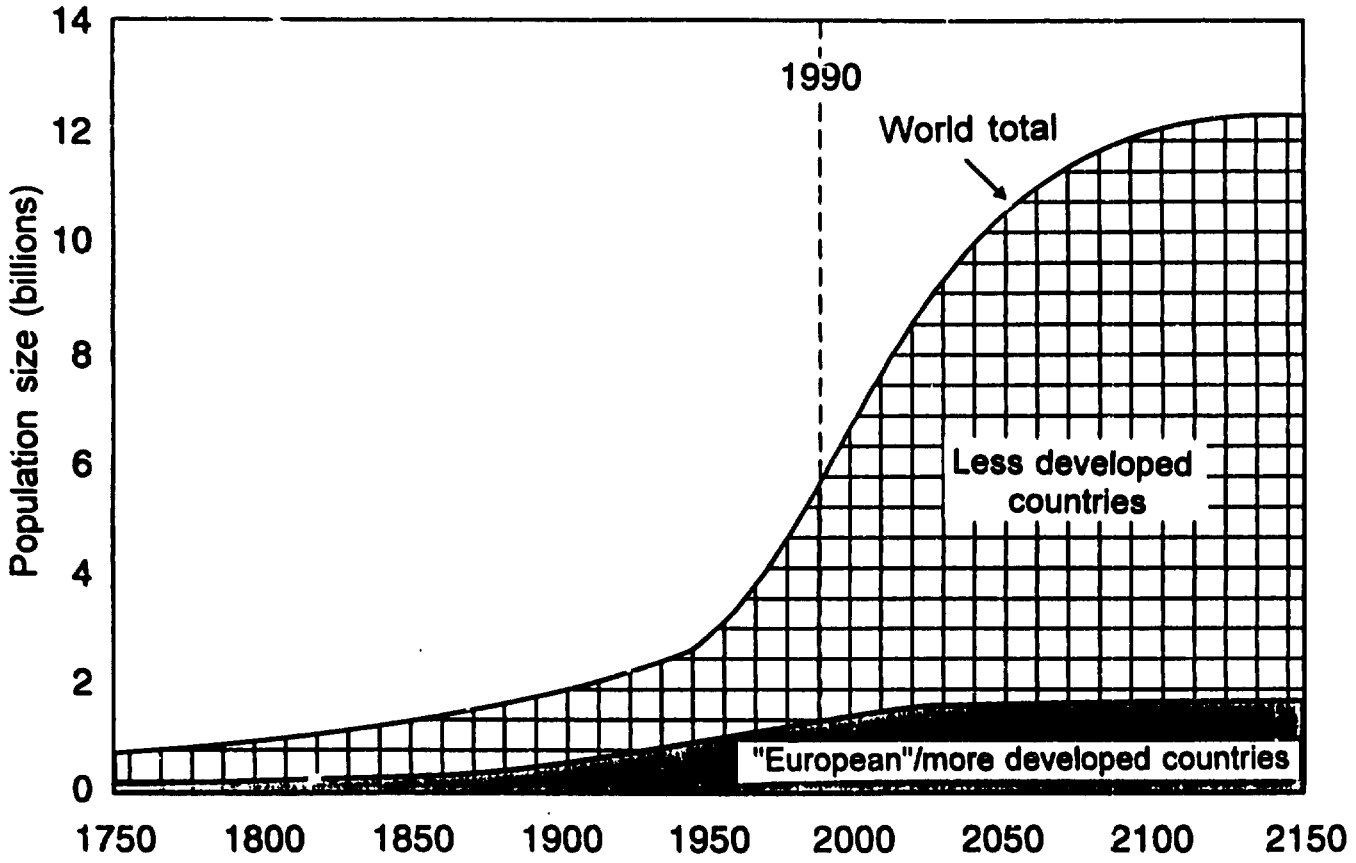
It is generally accepted that green revolution technologies and associated policies played a major role in feeding the growing population in the past. A combination of high-yielding varieties, fertilizers, irrigation, plant protection materials and improved management practices allowed crop yields to increase significantly and thereby facilitated the increased production of food grains from the limited cultivable lands. Although high-yielding varieties were instrumental in raising the potential yields of several crops, including wheat, rice, maize and sorghum, the realization of that potential depended on heavy applications of fertilizers in well-irrigated areas. Without adequate and timely supply of fertilizers and water, the actual yield of high-yielding varieties was significantly lower than that of the traditional varieties. It is not, therefore, coincidental that global fertilizer use increased more than fivefold, from 27.4 million tonnes in 1959/60 to 145.6 million tonnes in 1988/89.* During the same period, harvested area under cereals increased from 661 million ha in 1961 to 696 million ha in 1991, whereas cereal production increased from 884 million tonnes in 1961 to 1,884 million tonnes in 1991. It is obvious that rapid growth in fertilizer use has played and will continue to play a lead role in feeding the increasing population.

In addition to feeding the future population, fertilizers will also play an important role in protecting the resource base. It is estimated that about 1.2 billion hectares, or 10 per cent, of the earth's most productive soil has been damaged and can be restored to productive use only at a great cost [1]. Nearly three fourths of this damaged soil is in the developing countries. Improper agricultural practices, overgrazing and deforestation have contributed to this degradation of the resource base, as has inadequate replenishment of the removed nutrients. In many developing countries, especially sub-Saharan Africa, nutrient removal exceeds replenishment by a factor of 3 or 4. The soils in sub-Saharan Africa are being mined at an annual rate of 8-9 million tonnes of nutrients [2]. Used in conjunction with other measures to replenish the removed nutrients, fertilizers can prevent the degradation of this resource. Besides, by promoting intensive agriculture in high-potential areas, well-managed fertilizer use can reduce pressures on marginal areas and on habitat-rich forests, which are currently being destroyed by resource-poor farmers to carve out a subsistence living.

Because the future challenges of food security and environmental protection, especially the preservation of the resource base, will be faced mostly by developing countries, it is there that growth in fertilizer use becomes crucial. To promote that growth, those countries must ensure an adequate supply of fertilizer nutrients through domestic production or trade or a combination thereof. However, because the developed countries are making little additional investment in production capacity and in some cases are registering declines in existing capacity, the burden of supplying fertilizers will fall

*Economic dislocations in the one-time centrally planned economies of the former Soviet Union and eastern Europe have reduced fertilizer use drastically in those places and caused global fertilizer use to decline continuously after 1988/89, sinking to 125.9 million nutrient tonnes in 1992/93.

Figure I. World: population growth estimates (1750-1990) and projections (1990-2150)



Source: J. Bongaarts, "Global and regional population projections to 2025", Paper presented at the IFPRI Round Table on Population and Food Security in the Early 21st Century, Washington, D.C., 14-16 February 1994.

heavily on the developing countries themselves. This paper focuses on the trends in and patterns of fertilizer use and production in the developing countries, factors affecting those trends and patterns, and the policy environment needed to promote environmentally sustainable growth in fertilizer use and supply in the future.

I. Development patterns of the fertilizer industry in the developing countries

A. Trends in fertilizer use

1. Global context

Global fertilizer use increased from 27.4 million tonnes in 1959/60 to 145.6 million tonnes in 1988/89 and then gradually decreased to 125.9 million tonnes in 1992/93. This recent decline in global fertilizer use was a result of drastic reductions in fertilizer use in the one-time centrally planned economies of eastern Europe and the former Soviet Union, brought about by the disintegration of economic and institutional arrangements and the resulting policy and institutional instability in those economies [3].

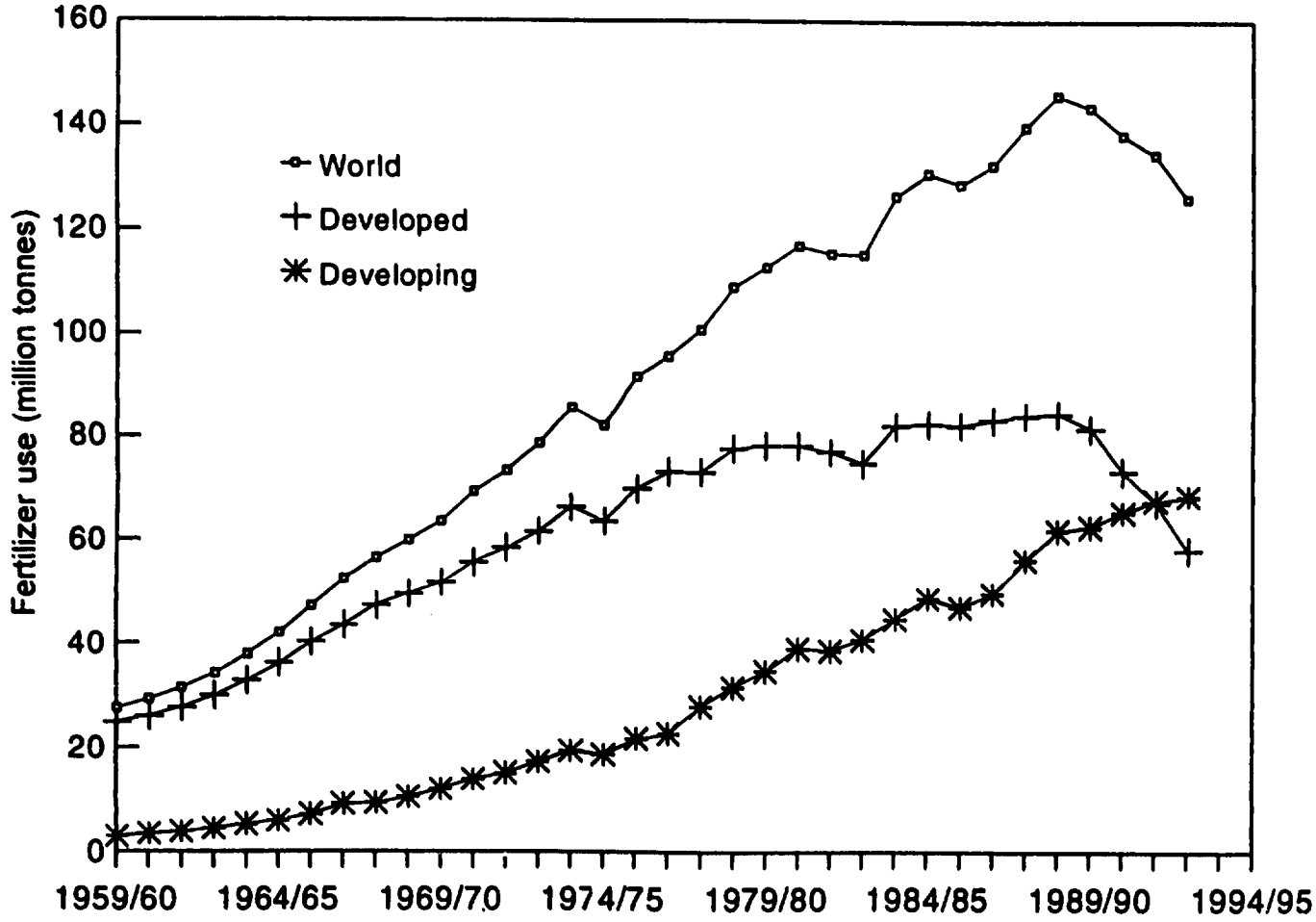
Both the developed and the developing countries increased their fertilizer use, but the latter increased it at a higher rate and surpassed the developed countries in 1991/92 (figure II). By 1992/93, the developing countries' share of global fertilizer use had grown to 54 per cent, in contrast to 10 per cent in 1959/60 and 31 per cent in 1979/80.

In 1959/60, the developing countries used less than 3 million tonnes of fertilizer nutrients, and most of it was concentrated on export crops. The launching of the green revolution in the mid-1960s in India, and later in other Asian countries, accelerated the growth of fertilizer use in the developing countries: it increased to 11.9 million tonnes in 1969/70 and 34.4 million tonnes in 1979/80. The growing demand for food grains, attributable to population and income growth, and the limited scope for expanding crop areas, especially in Asia, meant that crop yields would have to be raised through increased fertilizer use and associated measures, such as high-yielding varieties, irrigation and plant protection materials. As a result, fertilizer use nearly doubled in the next 13 years, growing at an annual compound rate of 5.2 per cent, from 34.4 million tonnes in 1979/80 to 68.2 million tonnes in 1992/93. This performance is in striking contrast to the poor performance of the developed countries, where fertilizer use increased at an annual compound rate of only 0.8 per cent, from 78 million tonnes in 1979/80 to 84 million tonnes in 1988/89, and then decreased at an annual rate of 9.4 per cent to 57.7 million tonnes by 1992/93. This poor performance of the developed countries is due to several factors, including grain surpluses, low crop prices, saturated markets and, most importantly, the disintegration of economic and institutional arrangements in the fertilizer sectors of eastern Europe and the former Soviet Union.

2. Regional patterns

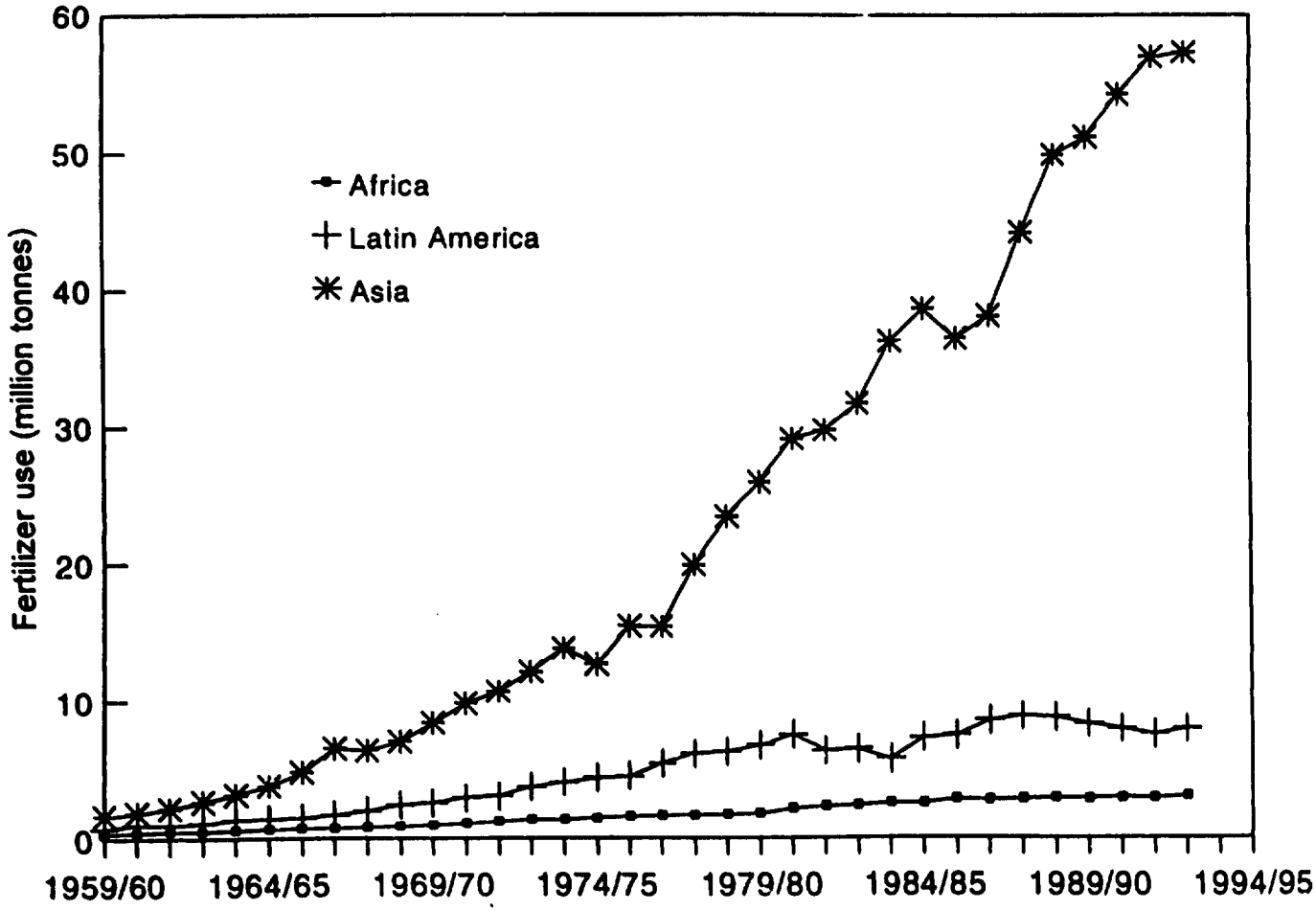
Although fertilizer use increased at an annual rate of over 5 per cent, or 2.6 million tonnes, in the developing countries during the 1979/80-1992/93 period, not all regions recorded good performance (table 1). In relative as well as absolute terms, Asia dominated the performance of the developing countries (figures III and IV). In Asia, fertilizer use increased by 31.4 million tonnes, from 25.9 million tonnes in 1979/80 to 57.3 million tonnes in 1992/93, Asia thereby having contributed about 93 per cent of the increase in fertilizer use in the developing countries. Such an excellent performance made Asia not only the leading region in the developing world (figure V) but

Figure II. World: fertilizer use by economic region, 1959/60-1992/93



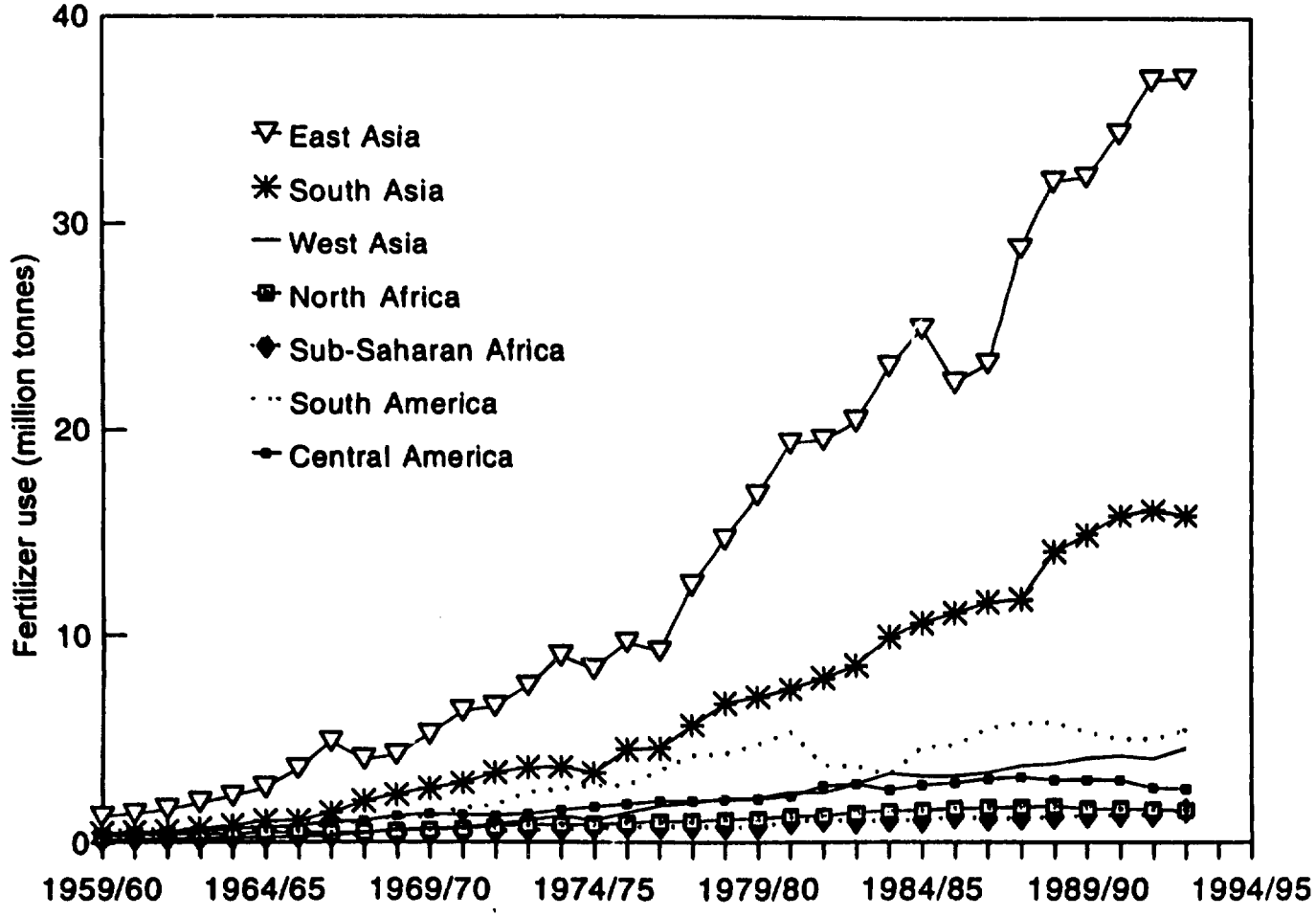
Source: FAO, *Fertilizer Yearbook*, various years.

Figure III. Developing countries: fertilizer use by region, 1959/60-1992/93



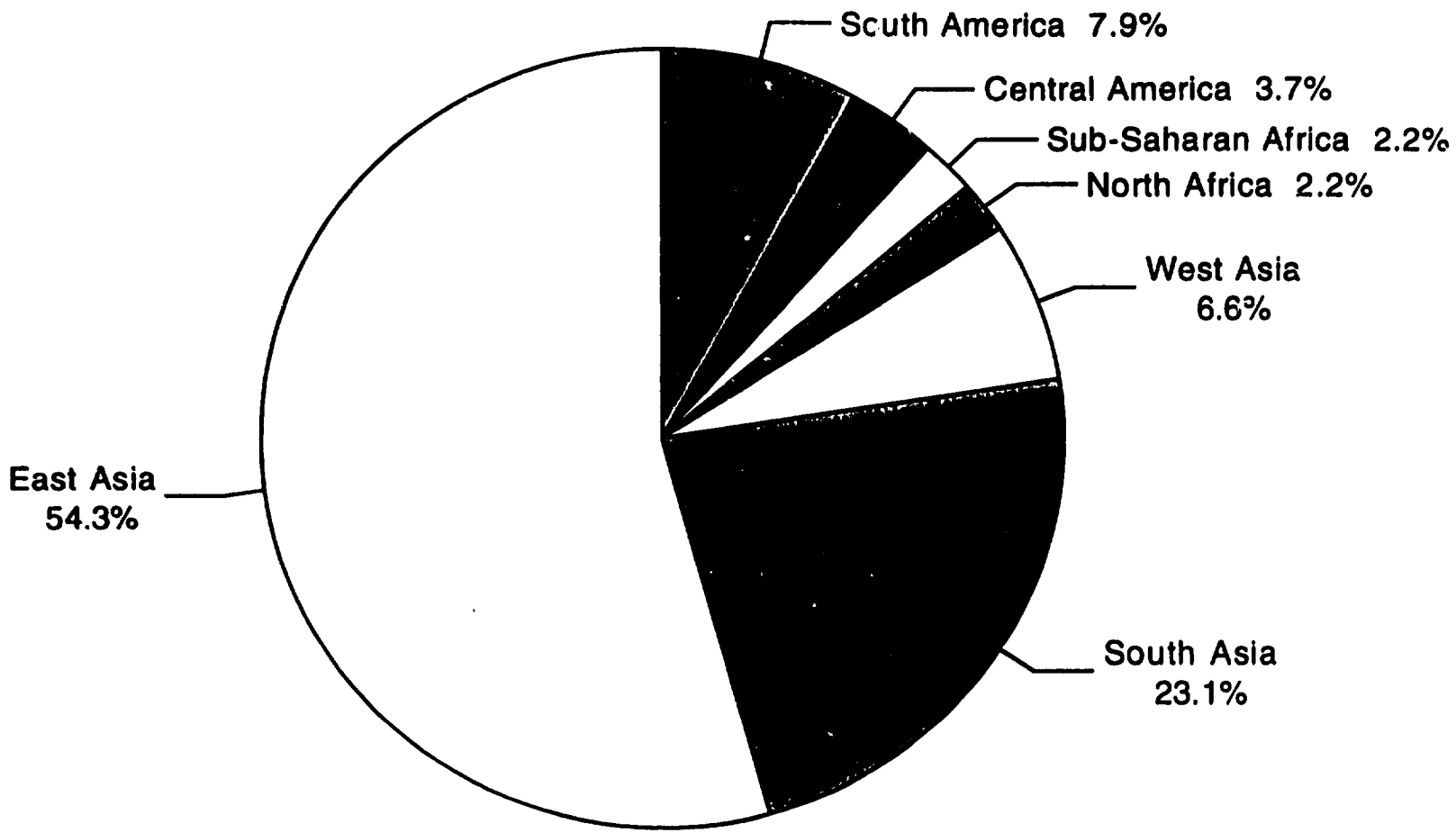
Source: FAO, *Fertilizer Yearbook*, various years.

Figure IV. Developing countries: fertilizer use by disaggregated region, 1959/60-1992/93



Source: FAO, *Fertilizer Yearbook*, various years.

Figure V. Developing countries: regional shares in fertilizer use, 1992/93



Source: FAO, *Fertilizer Yearbook*, 1993.

also a dominant region in the whole world [3]. In large part, Asia's performance was due to the stable and supportive policy environment experienced by most Asian countries, including China, India, Indonesia, Pakistan and Saudi Arabia.

Table 1. Developing countries: fertilizer use by region, 1959/60-1992/93
(Thousands of tonnes)

Region	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Africa	331	936	1 820	2 833	2 994
North Africa	230	560	1 085	1 585	1 497
Sub-Saharan Africa	101	376	735	1 248	1 497
Asia	1 674	8 391	25 877	51 098	57 276
East Asia	1 190	5 183	16 780	32 247	37 018
South Asia	406	2 571	6 977	14 820	15 749
West Asia	78	637	2 120	4 031	4 509
Latin America	726	2 546	6 740	8 257	7 907
Central America	293	1 341	2 057	2 980	2 517
South America	433	1 205	4 683	5 277	5 390
Total	2 731	11 873	34 437	62 188	68 177

Source: FAO, *Fertilizer Yearbook*, various years.

In contrast to Asia, Latin America experienced wide fluctuations and little growth in fertilizer use. This was due to a nonsupportive and unstable policy environment. Debt crises, rapid devaluation, subsidy removal, inadequate credit support and declining prices for agricultural exports were the major factors responsible for this poor performance. Inadequate fertilizer supply from the former Soviet Union to Cuba also had an adverse impact.

In Africa, especially in sub-Saharan Africa, fertilizer use increased only modestly in absolute terms. In sub-Saharan Africa, it went from 0.7 million tonnes in 1979/80 to 1.5 million tonnes in 1992/93; in spite of this doubling, the region has the lowest fertilizer use intensity (about 11 kg/ha) in the developing world (figure VI). Furthermore, it experienced little growth between 1981/82 and 1986/87, when its fertilizer use stagnated at around 1 million tonnes of nutrients. Foreign exchange shortages, low crop prices and inadequate institutional and physical infrastructures have kept fertilizer use at low levels. Policy instability resulting from structural adjustment programmes also played a major part in declining fertilizer use in several countries, including Cameroon, Ghana and Zambia. Unlike Asian countries, most countries in sub-Saharan Africa have inadequate "political commitment" to promote growth in fertilizer use, as reflected in the region's excessive dependence on fertilizer aid: more than half of the countries in sub-Saharan Africa depend on it to meet more than half of their domestic needs (table 2). Such excessive dependence on fertilizer aid also introduces uncertainty in fertilizer use because most fertilizer aid commitments are short-term and ad hoc. Given Africa's need for food security and environmental protection (preservation of the resource base), every effort should be made to promote rapid growth (10-15 per cent per annum) in fertilizer use. This will require a high degree of political commitment to ensure a conducive policy environment consisting of macroeconomic stability, price incentives, credit support, efficient organizations, and adequate supply of physical and institutional infrastructures. Because many countries depend on fertilizer imports, ensuring adequate and timely supply of foreign exchange is also important.

Figure VI. Developing countries: per hectare fertilizer use, 1992 (kg/ha)

Source: FAO, *Fertilizer Yearbook*, 1993, and *Production Yearbook*, 1993.

Table 2. Sub-Saharan Africa: dependency of countries on fertilizer aid, 1985-1990

Fertilizer aid / Fertilizer imports x 100	*Number of countries*		
	1985	*1987*	*1990*
0	7	8	6
1-20	3	4	3
20-50	2	1	2
50-80	3	5	7
80-99	2	2	0
100	23	20	22
Total	40	40	40

Source: Fertilizer Economic Studies, Ltd. (FERTECON), unpublished data.

3. Fertilizer use by nutrient

Nitrogen fertilizer use increased from 1.7 million tonnes in 1959/60 to 22.5 million tonnes in 1979/80 and 44.3 million tonnes in 1992/93 (table 3). During the same period, phosphate use increased from 0.8 million tonnes to 16.9 million tonnes and potash use from 0.3 million tonnes to 7.0 million tonnes. The relatively good and quick response of high-yielding varieties to nitrogen and the visibility of its impact on crop production made nitrogen fertilizer popular with farmers and contributed to its rapid growth. Domestic availability and favourable pricing also contributed to this process. The availability of phosphate and potash in the soils at the lower application rates of nitrogen made it unnecessary to use high levels of phosphate and potash. However, as many developing countries are using higher levels of nitrogen, increased use of phosphate and potash should be promoted.

Table 3. Developing countries: fertilizer use by nutrient, 1959/60-1992/93
(Thousands of tonnes)

Nutrient	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Nitrogen	1 669	7 515	22 524	40 683	44 269
Phosphate	762	3 084	8 276	15 223	16 929
Potash	300	1 274	3 637	6 283	6 979
Total	2 731	11 873	34 437	62 189	68 177

Source: FAO, *Fertilizer Yearbook*, various years.

Of the 68.2 million tonnes of fertilizer nutrients used by the developing countries in 1992/93, nitrogen fertilizers accounted for 44.3 million tonnes, or 65 per cent, and phosphate and potash fertilizers for 16.9 (25 per cent) and 7.0 (10 per cent) million tonnes, respectively. The dominance

of nitrogen in total fertilizer use indicates that developing countries are using fertilizers in an unbalanced manner (table 4). To improve the efficiency of fertilizer use and minimize the adverse environmental impact associated with fertilizers, the use of phosphate and potash should be promoted.

Table 4. Nitrogen:phosphate:potash ratio, 1990

Region/country	*Nitrogen:phosphate:potash*
Africa	
Cameroon	1.0:0.24:0.33
Egypt	1.0:0.26:0.05
Ghana	1.0:0.21:0.33
Kenya	1.0:0.73:0.22
Nigeria	1.0:0.47:0.44
Zambia	1.0:0.32:0.13
Asia	
Bangladesh	1.0:0.35:0.11
China	1.0:0.27:0.08
India	1.0:0.41:0.16
Indonesia	1.0:0.42:0.17
Pakistan	1.0:0.27:0.03
Turkey	1.0:0.52:0.05
Latin America	
Argentina	1.0:0.54:0.08
Brazil	1.0:1.57:1.54
Colombia	1.0:0.42:0.65
Cuba	1.0:0.22:0.58
Mexico	1.0:0.28:0.07
Venezuela	1.0:0.79:0.64

Source: B. L. Bumb, "Global fertilizer perspective, 1980-2000: the challenges in structural transformation", IFDC, unpublished draft, 1994.

B. Trends in fertilizer production

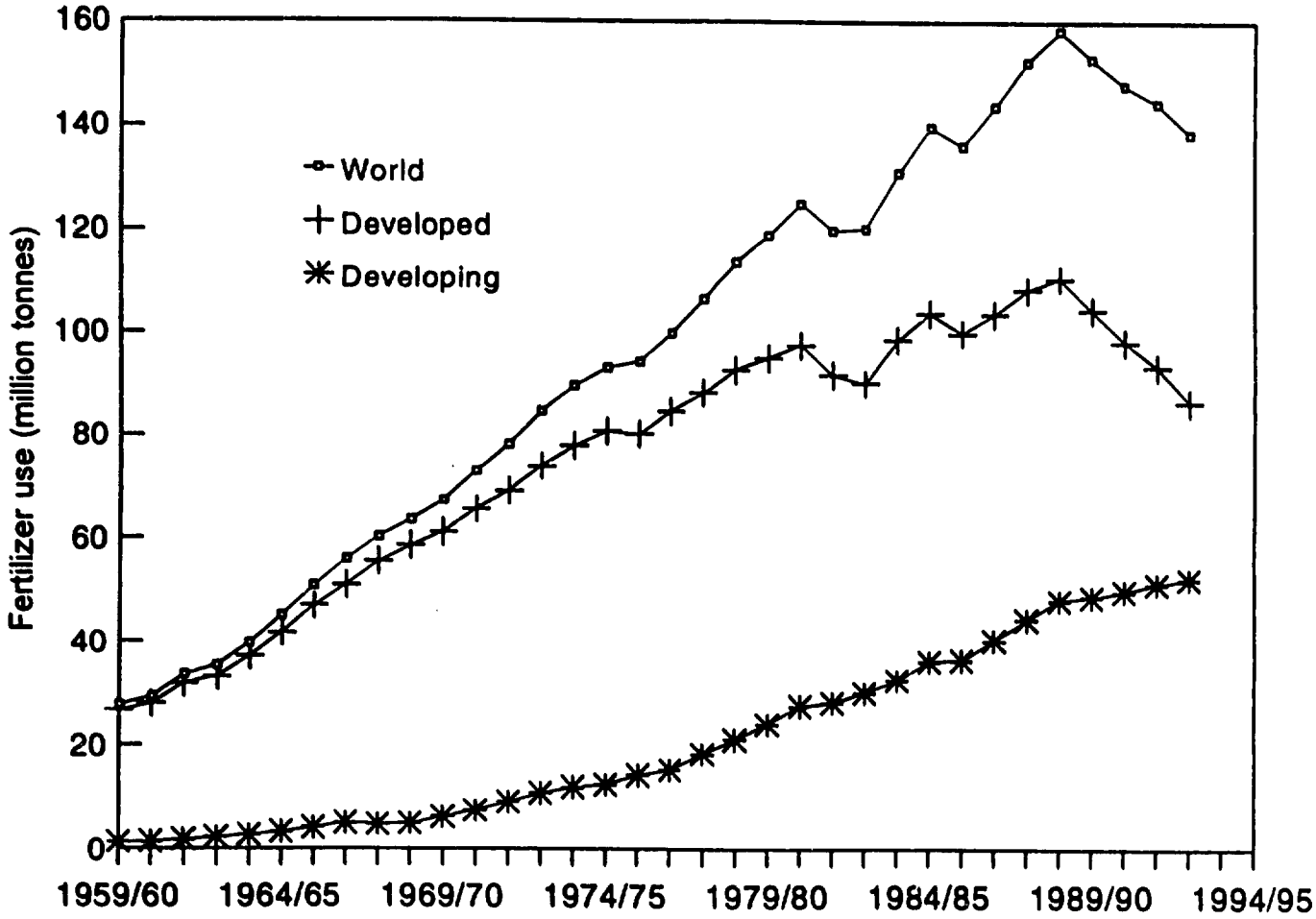
1. Global context

Rapid growth in fertilizer use in the 1960s and the 1970s also stimulated rapid growth in fertilizer production. Global fertilizer production increased from 27.7 million tonnes in 1959/60 to 118.7 million tonnes in 1979/80 (figure VII). During the 1980s it increased more slowly, until it reached 158.2 million tonnes in 1988/89. In the following four years, it decreased by about 20 million tonnes. This decrease was caused by a decrease in fertilizer production due to economic disintegration in eastern Europe and the former Soviet Union.

Until the late 1980s, fertilizer production increased in both the developed and the developing countries. Thereafter, it decreased rapidly in the developed countries owing to a fall in production in the former centrally planned economies.

In the developing countries, fertilizer production increased from 1.2 million tonnes in 1959/60 to 24 million tonnes in 1979/80. In the next 13 years, it more than doubled, reaching 52 million

Figure VII. World: fertilizer production by economic region, 1959/60-1992/93



Source: FAO, *Fertilizer Yearbook*, various years.

tonnes in 1992/93. Consequently, the developing countries' share in global production increased from 2 per cent in 1959/60 to 20 per cent in 1979/80 and 38 per cent in 1992/93. Despite this significant increase, their production, unlike their consumption, is still less than that of the developed countries. This reflects both the limited resource base (raw materials) and the inadequate foreign exchange that many developing countries have for fertilizer production, especially phosphate and potash production, which forces them to depend on fertilizer trade to meet their requirements. This situation lends importance to the role of macroeconomic policy in developing a fertilizer supply strategy. From the point of view of creating a conducive policy environment for the industry, it should be mentioned that most fertilizer production in developing countries occurred in the public sector.

2. Regional patterns

Like fertilizer use, fertilizer production in the developing countries is also concentrated in Asia: in 1992/93, it accounted for 83 per cent of the fertilizer production in the developing countries (figure VIII). Asia also commands a dominant share of global fertilizer production, although its share of production (31 per cent) is much smaller than its share of consumption (44 per cent) [3]. Latin America and Africa account for relatively modest shares, and most of Africa's fertilizer production is concentrated in North Africa, with Morocco being the largest producer of phosphate fertilizers.

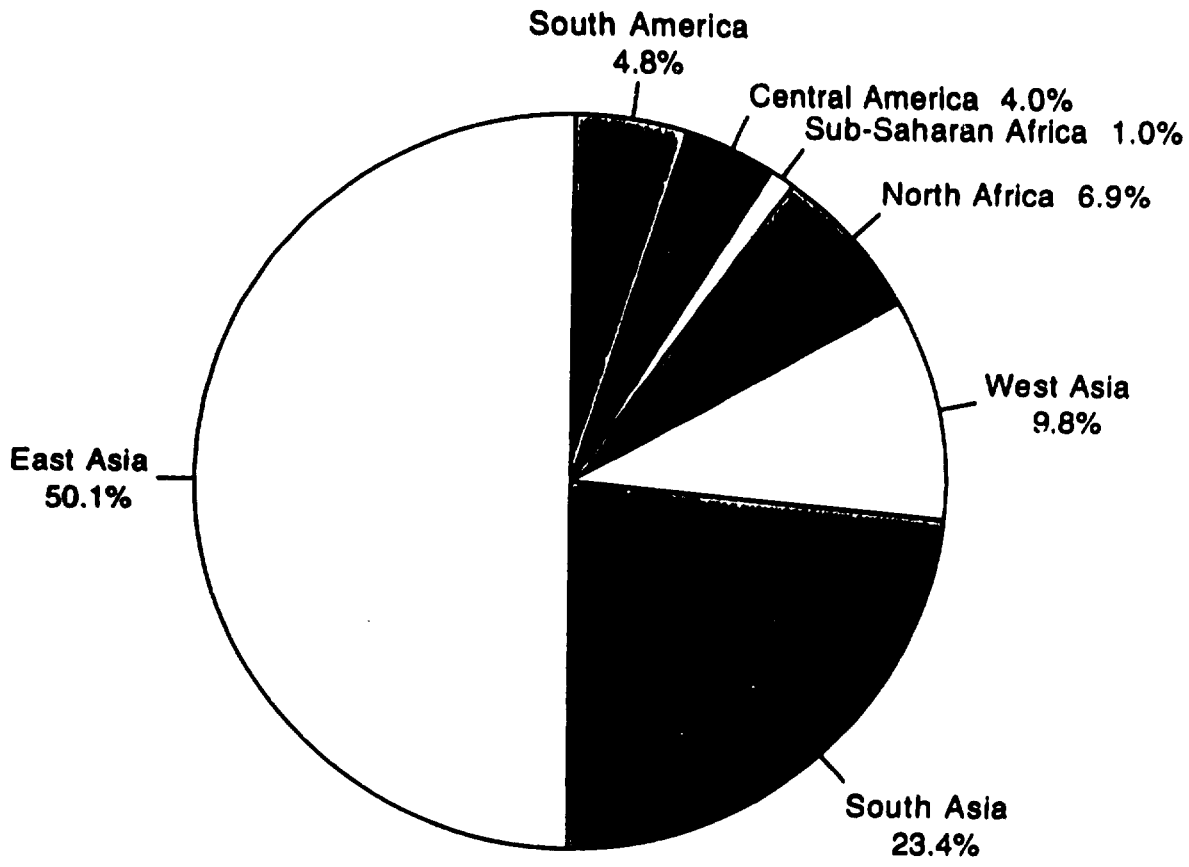
In Asia, fertilizer production increased rapidly during the 1970s and the 1980s (figures IX and X and table 5). Many Asian countries were motivated to invest in fertilizer production facilities to ensure the adequate and timely supply of fertilizers, especially nitrogen fertilizers, that would allow adopting and spreading green revolution technologies. The availability of natural gas also facilitated this expansion. Because fertilizer investments are foreign-exchange-intensive, World Bank support for constructing fertilizer plants provided added stimulus [4]. In addition, the West Asian countries that are rich in oil and natural gas also invested in fertilizer production for export. Consequently, fertilizer production increased from 4.3 million tonnes in 1969/70 to 19.7 million tonnes in 1979/80 and 43.3 million tonnes in 1992/93. Nitrogen production accounts for the lion's share.

Table 5. Developing countries: fertilizer production by region, 1959/60-1992/93
(Thousands of tonnes)

Region	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Africa	157	661	1 092	3 810	4 121
North Africa	156	524	915	3 321	3 590
Sub-Saharan Africa	1	137	177	489	531
Asia	646	4 301	19 710	39 663	43 309
East Asia	466	2 930	14 020	23 724	26 049
South Asia	159	1 132	3 767	10 738	12 168
West Asia	21	239	1 923	5 201	5 092
Latin America	390	1 164	3 122	5 128	4 613
Central America	25	689	1 108	2 373	2 097
South America	365	475	2 014	2 755	2 516
Total	1 193	6 126	23 924	48 601	52 043

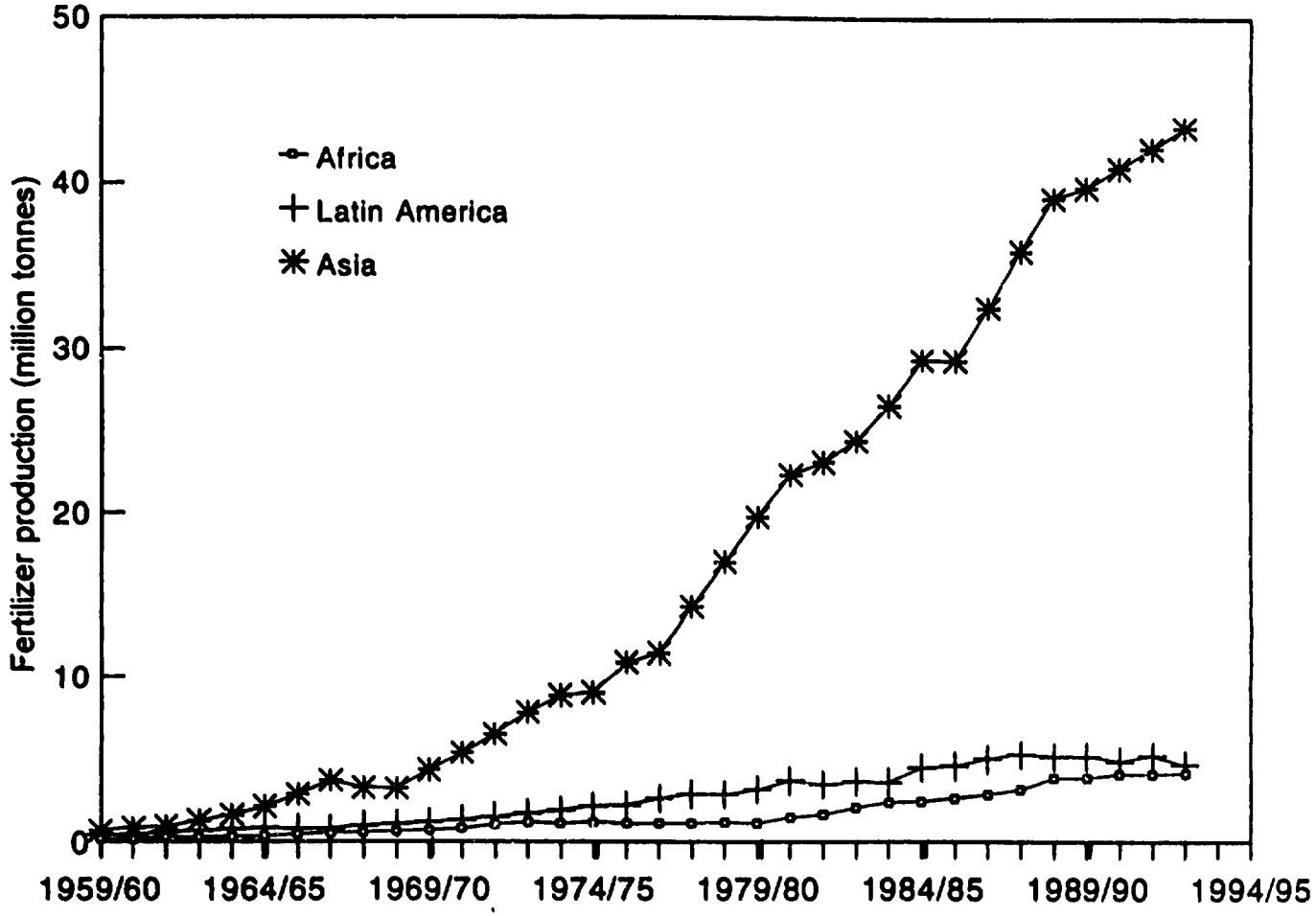
Source: FAO, *Fertilizer Yearbook*, various years

Figure VIII. Developing countries: regional shares of fertilizer production, 1992/93



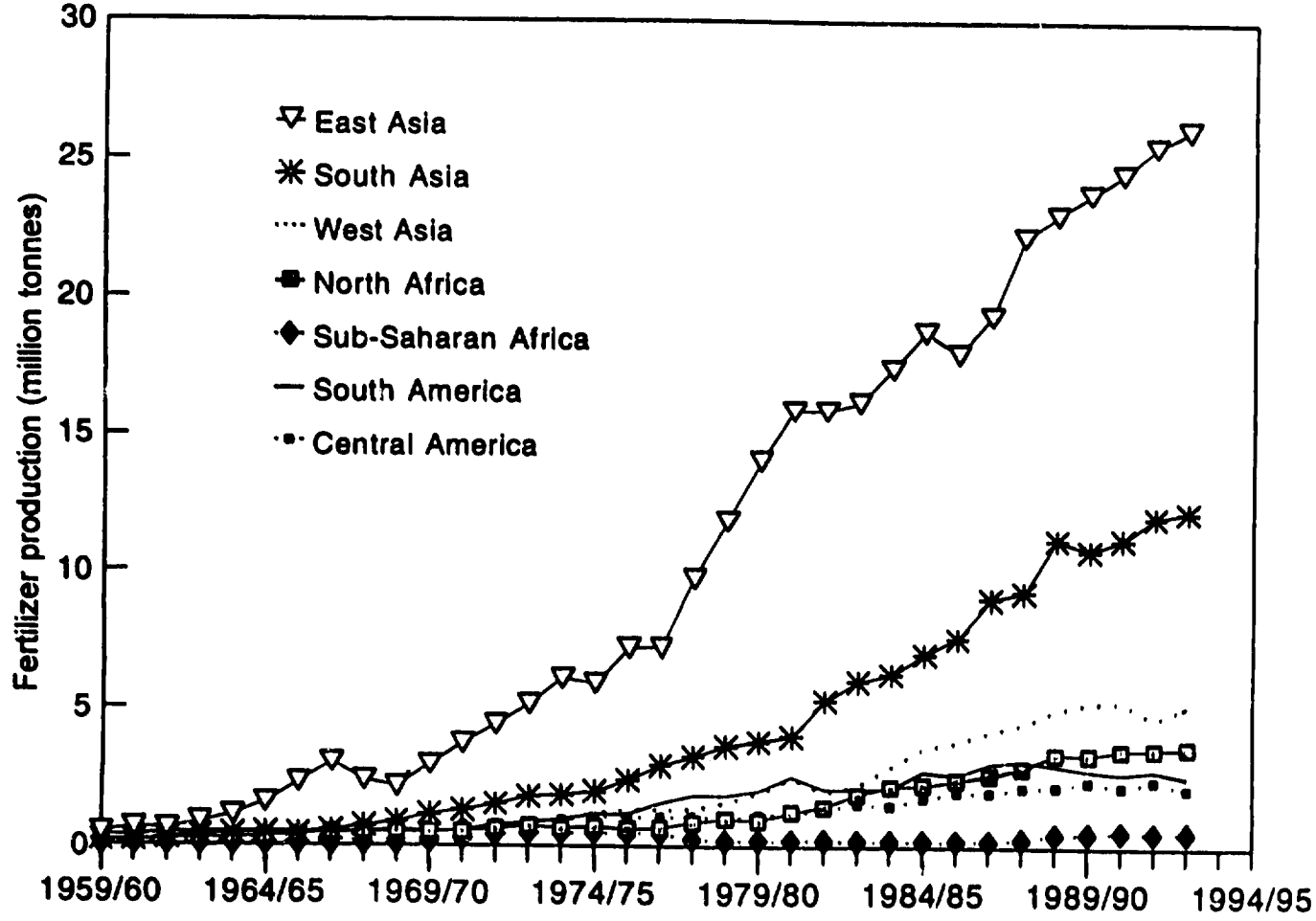
Source: FAO, *Fertilizer Yearbook*, 1994.

Figure IX. Developing countries: fertilizer production by region, 1959/60-1992/93



Source: FAO, *Fertilizer Yearbook*, various years.

Figure X. Developing countries: fertilizer production by disaggregated region, 1959/60-1992/93



Source: FAO, *Fertilizer Yearbook*, various years.

Fertilizer production increased rapidly in Latin America until the early 1980s and slowly thereafter. Unstable demand and foreign exchange shortages due to debt crises and declining export revenues have had an adverse impact on fertilizer production in the region. Declining fertilizer prices also affected fertilizer production, especially in Central America, where a large proportion of production is geared to exports.

Fertilizer production in Africa is concentrated in North Africa, which accounted for 88 per cent of the production in 1992/93. In sub-Saharan Africa, only Nigeria has a large-scale ammonia-urea plant, which produces about 270,000 tonnes of nitrogen. Senegal has large capacities for phosphate production. Other countries produce modest quantities in small plants. In 1992/93, sub-Saharan Africa produced 0.5 million tonnes of nutrients, about 1 per cent of total production in the developing countries. In contrast, North Africa produced nearly 3.6 million tonnes of nutrients in the same year. Morocco and Tunisia are major producers of phosphate fertilizers, whereas Egypt and the Libyan Arab Jamahiriya produce nitrogen fertilizers. A large proportion of the phosphate fertilizer produced in this region is exported to other countries. Many countries in sub-Saharan Africa are rich in phosphate rock, a crucial raw material for producing phosphate fertilizers. However, because of low domestic demand and global surpluses, which lead to low and unremunerative prices, the rock deposits have not been developed. Nevertheless, they could be a good source of material for direct application to restore and sustain soil fertility. A better policy environment and greater political commitment are needed to tap this resource.

3. Fertilizer production by nutrient

Like fertilizer use, fertilizer production is dominated by nitrogen. In 1992/93, the developing countries produced 37.7 million tonnes of nitrogen, 13.2 million tonnes of phosphate and 1.1 million tonnes of potash (table 6). Thus, nitrogen production accounted for over 70 per cent of total fertilizer production.

Table 6. Developing countries: fertilizer production by nutrient, 1959/60-1992/93
(Thousands of tonnes)

Nutrient	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Nitrogen	736	3 872	17 724	35 457	37 725
Phosphate	439	2 167	6 160	12 168	13 258
Potash	18	87	40	976	1 060
Total	1 193	6 126	23 924	48 601	52 043

Source: FAO, *Fertilizer Yearbook*, various years.

Nitrogen production increased from 3.9 million tonnes in 1969/70 to 17.7 million tonnes in 1979/80 and 37.7 million tonnes in 1992/93. In contrast, during the same period, phosphate production increased from 2.2 million tonnes to 13.2 million tonnes and potash production increased from 87,000 tonnes to 1.1 million tonnes. Limited availability of potash ores and phosphate rock constrained phosphate and potash production. By contrast, the widespread availability of natural gas, followed by rapid growth in nitrogen use, facilitated the rapid growth in nitrogen production. The limited production base for phosphate and potash fertilizers forces many developing countries to depend on fertilizer imports from the developed countries to meet domestic requirements. Owing to

foreign exchange shortages, however, many countries restrict fertilizer imports, creating imbalances in nutrient use.

C. Trends in fertilizer trade

Although fertilizer production increased rapidly in the developing countries, it was not sufficient to meet the growing demand for fertilizer. Consequently, fertilizer trade has also increased (figure XI). Net fertilizer imports (imports less exports) increased from 1.3 million tonnes in 1959/60 to 11.0 million tonnes in 1979/80 and 17.4 million tonnes in 1992/93. In gross terms, fertilizer imports increased from 2.5 million tonnes in 1959/60 to 25.0 million tonnes in 1992/93, whereas fertilizer exports increased from 0.3 million tonnes to 7.6 million tonnes in the same period. While growing demand stimulated fertilizer imports, the availability of natural gas and phosphate rock, especially in West Asia and North Africa, stimulated fertilizer exports.

Until 1979/80, net fertilizer imports increased in all regions (table 7). However by 1989/90, North Africa and West Asia had become net exporters and exported about 1.6 and 1.2 million tonnes, respectively. In terms of individual nutrients, West Asia is a major exporter of nitrogen fertilizers and North Africa of phosphate fertilizers. The abundance of natural gas and phosphate rock in these regions, the high prices of the mid-1970s and growing fertilizer demand in Asia and other regions made them major exporters. Foreign exchange needs also contributed to increased fertilizer exports from these regions.

Table 7. Developing countries: net fertilizer imports by region, 1959/60-1992/93 a/
(Thousands of tonnes)

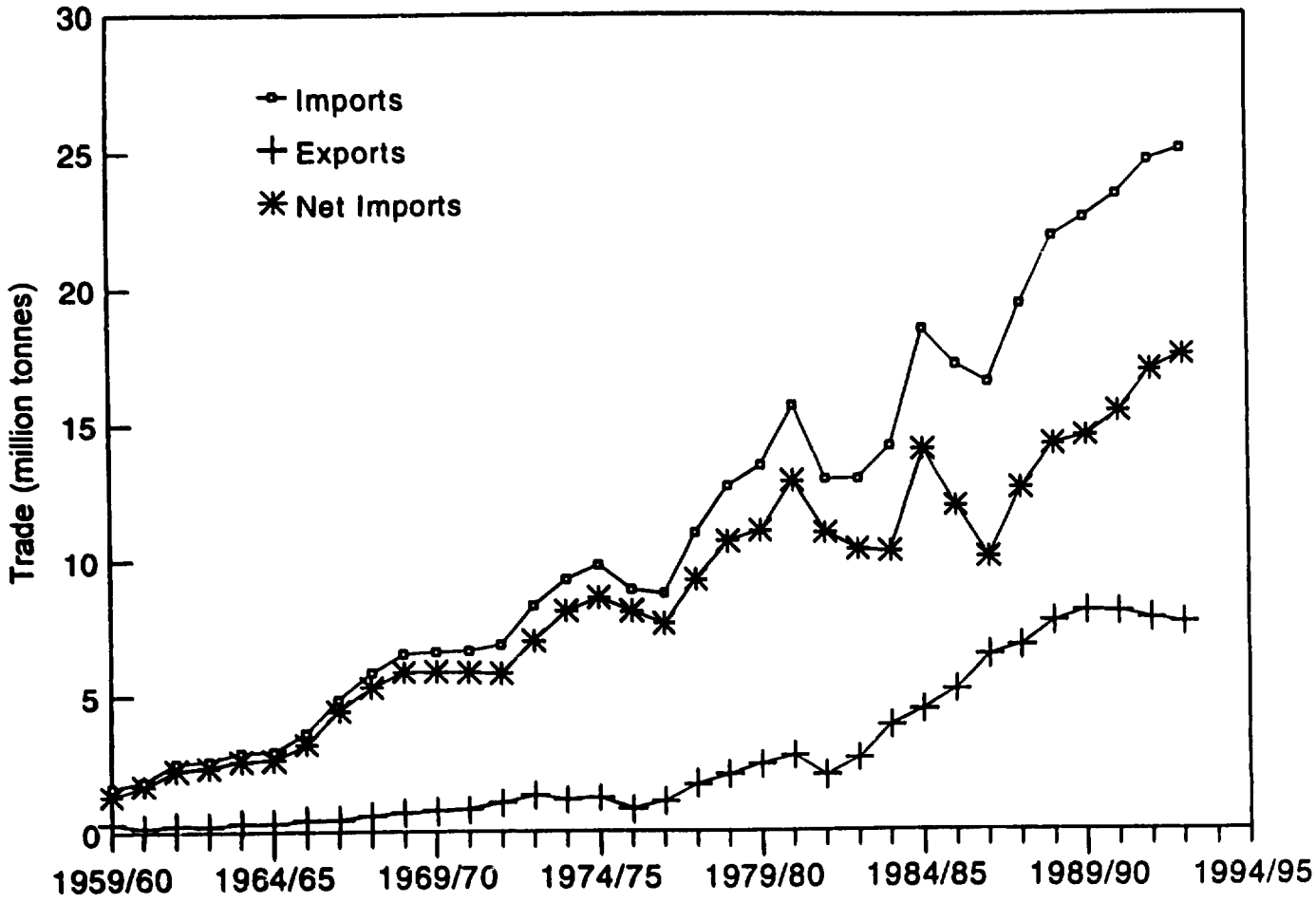
Region	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Africa	173	336	780	(721)	(1 092)
North Africa	72	22	154	(1 608)	(2 097)
Sub-Saharan Africa	101	314	626	887	1 005
Asia	1 090	4 154	6 613	11 900	15 082
East Asia	759	2 368	3 045	9 020	11 356
South Asia	272	1 388	3 120	4 083	4 075
West Asia	59	398	448	(1 203)	(349)
Latin America	57	1 410	3 639	3 281	3 446
Central America	124	671	982	837	432
South America	(67)	739	2 657	2 444	3 014
Total	1 320	5 900	11 032	14 460	17 436

Source: FAO, *Fertilizer Yearbook*, various years.

a/ Net imports = imports less exports. ( ) = net exports.

South America, South Asia, East Asia and sub-Saharan Africa remained and will continue to remain large net importers. Lack of raw materials for phosphate and potash production also makes these regions dependent on imports, although the small size of the markets, foreign exchange shortages and unfavourable policy environments have kept fertilizer imports low in sub-Saharan Africa.

Figure XI. Developing countries: fertilizer trade, 1959/60-1992/93



Source: FAO, *Fertilizer Yearbook*, various years.

Asia in general and East Asia in particular dominate the fertilizer trade in the developing countries. Asia accounted for 87 per cent of the net fertilizer imports in 1992/93; of these, East Asia accounted for 75 per cent. South Asia and South America are the other two dominant regions. Although sub-Saharan Africa comprises more than 40 countries, it accounts for less than 6 per cent of the trade in the developing countries.

Net imports of all three nutrients increased between 1959/60 and 1992/93 (table 8). However, nitrogen imports dominated until 1979/80. During the 1980s, potash imports increased rapidly, to reach 6.6 million tonnes in 1992/93. Increased imports in Asia, especially in China and India, contributed to this growth. Nitrogen imports increased from 5.4 million tonnes in 1979/80 to 6.9 million tonnes in 1992/93, and phosphate imports increased from 2.1 to 3.9 million tonnes during the same period. The more rapid growth in potash imports is partly a result of the heavy concentration of potash resources in a few countries: Belarus, Canada and the Russian Federation account for nearly two thirds of the current world production of potash fertilizers. Most developing countries have too little raw material to engage in potash production.

Table 8. Developing countries: net fertilizer imports by nutrient, 1959/60-1992/93 a/
(Thousands of tonnes)

Nutrient	*1959/60*	*1969/70*	*1979/80*	*1989/90*	*1992/93*
Nitrogen	818	3 898	5 417	5 623	6 922
Phosphate	215	799	2 070	3 127	3 893
Potash	287	1 203	3 545	5 710	6 621
Total	1 320	5 900	11 032	14 460	17 436

Source: FAO, *Fertilizer Yearbook*, various years.

a/ Net imports = imports less exports.

D. Outlook

Fertilizer demand in the developing countries is projected to grow at an annual rate of 3.1 per cent, from 62.1 million tonnes in 1989/90 and 68.2 million tonnes in 1992/93 to 83.4 million tonnes in 2000 and 115.2 million tonnes in 2010 (table 9). Except for China, most of the regions are expected to register annual growth between 3.5 and 4.8 per cent. Because of high fertilizer use levels, China's fertilizer market is nearly saturated and therefore may not see high growth. South Asia is projected to increase its fertilizer use by about 18 million tonnes and Latin America by over 7 million tonnes. In spite of having the highest annual growth, sub-Saharan Africa will have the lowest absolute increase, about 2 million tonnes.

As indicated earlier, the developing countries as a group are net importers of fertilizers, although import dependence varies from one region to another and from one nutrient to the other. South Asia, East Asia, South America and sub-Saharan Africa are deficient in all three nutrients, whereas North Africa, Central America and West Asia are exporters of phosphate and nitrogen fertilizers.

The projections of supply potential developed by the World Bank/Food and Agriculture Organization of the United Nations (FAO)/UNIDO/Industry Fertilizer Working Group (hereinafter referred to as the Fertilizer Working Group) suggest that the developing countries will produce about

62.1 million tonnes of nutrients in the year 1998/99 (table 10). They will need to close the gap of 15.7 million tonnes of nutrients through additional capacity or imports or both.* Although there is scope for increasing nitrogen and phosphate production, the same is not true for potash production. Furthermore, since the scope for increasing economically viable nitrogen and phosphate production is limited in South Asia, South America and sub-Saharan Africa, these regions will have to rely on imports to meet their requirements, with the availability of foreign exchange and exchange rate stability playing a crucial role. These regions may be able to develop joint ventures, such as those developed by India and Senegal and by India and Oman.

Table 9. Developing countries: fertilizer demand projections, 1989/90, 2000 and 2010
(Millions of tonnes)

Region	*1989/90 (actual)*	*2000 a*	*2010*	*Annual growth 1990-2010 (%)*
Sub-Saharan Africa	1.2	1.9	3.3	4.8
Latin America	8.2	11.6	16.9	3.5
Near East/North Africa	5.6	8.4	13.1	4.1
South Asia	14.8	21.7	32.9	3.9
East Asia	32.3	39.8	49.0	2.1
Total	62.2	83.4	115.2	3.1

Source: FAO, *Agriculture toward 2010* (Rome, 1993). For "East Asia", demand projections for China by the World Bank/FAO/UNIDO/Industry Fertilizer Working Group were added to FAO projections for "East Asia, excluding China".

Note: Totals may not add due to rounding.

a/ Projected by using the annual growth rates for the 1989/90-2010 period.

*As the Fertilizer Working Group uses geographical classification, these data refer to the total of Africa, Asia, and Latin America, which are largely developing regions. Also, the demand projections made by the Fertilizer Working Group are different from those developed by FAO.

Table 10. World: supply/demand balances, 1998/99
(Millions of tonnes)

	Nutrient								
	Nitrogen			Phosphate			Potash		
Region	Supply	Demand	Balance	Supply	Demand	Balance	Supply	Demand	Balance
Africa a/	2.4	2.4	0	5.9	1.2	4.7	0	0.6	(0.6)
Asia	35.2	42.0	(6.8)	9.6	15.8	(6.2)	2.4	6.3	(3.9)
East b/	20.3	26.7	(6.9)	6.6	9.6	(3.0)	0.1	4.6	(4.5)
South	10.5	12.4	(1.9)	0.8	4.5	(3.7)	0	1.5	(1.5)
West c/	4.5	3.0	1.5	2.2	1.8	0.4	2.3	0.2	2.1
Latin America	4.2	4.3	(0.1)	1.9	2.8	(0.9)	(0.5)	2.4	(1.9)
Central	2.7	2.1	0.6	0.6	0.6	0	0	0.4	(0.4)
South	1.5	2.2	(0.7)	1.3	2.2	(0.9)	0.5	2.0	(1.5)
North America	11.7	12.1	(0.4)	10.2	4.9	5.3	10.7	5.2	5.5
Western Europe	6.2	8.5	(2.3)	2.4	3.3	(0.9)	5.7	3.7	2.0
Oceania	0.4	0.8	(0.4)	0.7	1.1	(0.4)	0	0.4	(0.4)
Eastern Europe	7.0	2.2	4.8	1.4	0.8	0.6	0	0.8	(0.8)
Former Soviet Union	12.1	5.2	6.9	5.2	3.2	2.0	6.1	2.3	3.8
World	79.2	77.5	1.7	37.0	33.0	4.0	25.5	21.6	3.9

Source: World Bank/FAO/UNIDO/Industry Fertilizer Working Group, "World and regional supply and demand balances for nitrogen, phosphate and potash, 1992/93-1998/99" (Washington, D.C., 1994).

Note: Totals may not add due to rounding. ( ) = deficit.

a/ Includes South Africa.

b/ Includes Japan.

c/ Includes Israel.

II. Factors affecting the growth of the fertilizer industry

The fertilizer industry is an all-encompassing industry: it affects and is affected by developments in agriculture, other industries, energy, the infrastructure, finance and trade and in the macroeconomy at large. Numerous factors affect its growth and performance; those that are particularly important are elaborated in detail.

A. Macroeconomic factors

The growth in fertilizer use and supply depends not only on micro-economic factors such as pricing, marketing and credit availability but also on the conduciveness and stability of macroeconomic factors such as the exchange rate, foreign exchange availability, inflationary pressures and capital markets. Of these, exchange rate stability is the most critical, followed by the availability of foreign exchange. The experience of many developing and reforming countries such as Brazil, Mexico, Poland, Russian Federation, Turkey and Zambia suggests that rapid devaluation of the domestic currency causes fertilizer use and production to drop sharply (figure XII). Although devaluation of the domestic currency increases incentives for fertilizer exports, it decreases domestic use by increasing prices of both domestically produced and imported fertilizers (table 11), with the result that domestic production also falls. Furthermore, the increased costs of imported raw material and capital investment have an adverse impact on fertilizer production. During such macroeconomic shocks, some safeguards or "safety nets" should be introduced so that the fertilizer industry is not annihilated altogether.

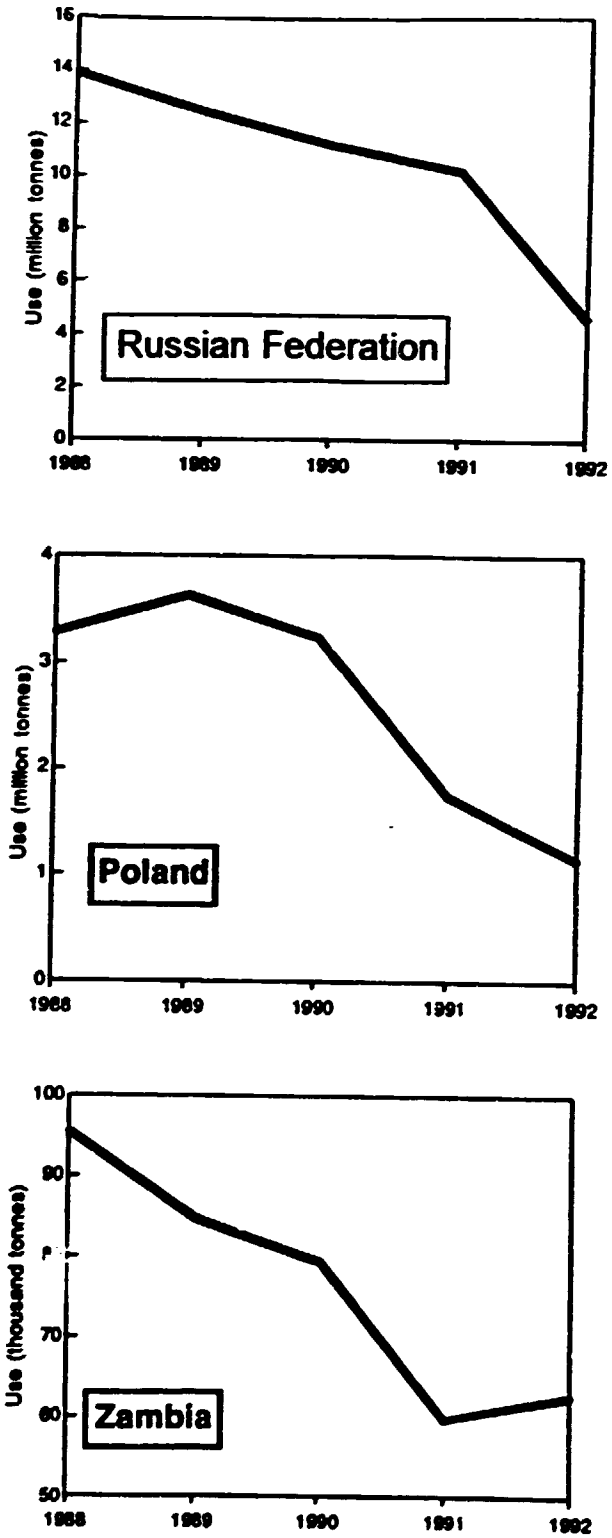
The shortage of foreign exchange is another macroeconomic factor that affects the performance of the fertilizer industry in many developing countries. Such shortages affect fertilizer industry operations in several ways:

Table 11. Exchange rates and nitrogen price in selected countries, 1985 and 1990

		Exchange rate (local currency/US$)			*Nitrogen price (local currency/tonne N)*		
Region/Country	*Local currency*	*1985*	*1989*	*% Change*	*1985*	*1990*	*% Change*
Asia							
Bangladesh	Taka	26.3	32.3	22.8	10 141	10 826	6.7
Turkey	Lira	522.0	2 121.7	306.5	112 970	552 174	388.8
Africa							
Ghana	Cedi	55.6	250.0	349.6	28 095	223 819	696.7
Zambia	Kwacha	0.9	12.9	1 333.3	1 125	16 696	1 384.1
Latin America							
Mexico	Peso	246.0	2 457.0	898.8	40 435	434 783	975.3
Venezuela	Bolivar	7.5	34.7	362.7	1 411	3 333	818.9
Eastern Europe							
Poland	Zloty	147.2	1 439.0	877.6	26 304	985 739	3 647.5

Source: International Monetary Fund, *International Financial Statistics*, annual publication; FAO, *Fertilizer Yearbook*, 1990.

Figure XII. Changes in fertilizer use during the reform process in selected countries, 1988-1992



Source: B. L. Bumb, "Global fertilizer perspective, 1980-2000: the challenges in structural transformation", IFDC, unpublished draft, 1994.

- Delays in getting adequate foreign exchange affect the construction cycle. In developed countries, a fertilizer plant (an ammonia-urea complex, for example) can be completed in 18-24 months; in developing countries, it could easily take 30-60 months. For example, the delay in getting foreign exchange has held up the construction of Nigeria's NAFCON II plant by several months.

- Foreign exchange shortages have forced many developing countries to approach different donors for the financing of the plant. Many donors tie their aid to the use of their own (i.e. donor) equipment and parts, and such arrangements can lead to incompatible and inefficient fertilizer plants. India's Haldia fertilizer plant is a classic example of such a situation. The construction of this plant started in 1972. Due to foreign exchange crises, efforts were made to maximize the use of indigenous equipment, and even limited imports were financed out of bilateral credits, leading to mismatches and the use of unproven equipment and machinery as well as design deficiencies. Although construction was completed in 1979, the lack of power meant commissioning could not start until 1981. Thereafter, various problems were encountered in various sections, and commissioning activities were stopped in 1986. Despite the expenditure of about Rs 7 billion (US$ 225 million at the current exchange rate), the plant has not become operational even after 22 years.

- An inadequate supply of foreign exchange generally results in shortages of spares and raw materials and, in turn, low capacity utilization. A World Bank study [5] found that fertilizer plants in Zimbabwe operated at near or higher than design capacity, whereas in Zambia the operating rates never exceeded 50 per cent. The main reason was that the Government of Zimbabwe assigned a top priority in allocating foreign exchange to the fertilizer industry, whereas the Zambian fertilizer industry always suffered from poor operation and maintenance due to a lack of spare parts, equipment and raw materials, a result of foreign exchange shortages.

Thus, the adequate and timely availability of foreign exchange is essential for both growth and optimum performance.

B. Pricing of fertilizers

After macroeconomic factors, pricing policy has the most critical influence on the growth and performance of the fertilizer industry. It affects the fertilizer industry in several ways:

- Fertilizer price affects incentives for both users and producers. On the one hand, higher prices can discourage farmers from using fertilizers, and lower prices can promote excessive fertilizer use, leading to environmental contamination. On the other hand, higher prices can stimulate production and lead to the introduction of environmental protection measures, whereas lower prices can reduce incentive to produce and ultimately lead to the closure of capacity, as happened in North America and western Europe in the mid- and late 1980s. Thus, the pricing of fertilizers poses the greatest challenge because it affects the interests of both producers and users (farmers) and, ultimately, those of society as a whole by virtue of its impact on fertilizer use and food production.

- Fertilizer price signals opportunities for new investment. Again, low prices can discourage investment in the expansion of capacity, whereas high prices can lead to excessive investment, as happened in the late 1970s and early 1980s.

- Pricing policy has a great impact on competitive marketing systems and marketing and distribution infrastructures, with highly regulated and unremunerative prices serving to discourage efficiency.

- Pricing policy affects the external trade in fertilizers.

It is clear from this impact analysis that fertilizer pricing policy affects different segments of the industry and society differently. Gains for the fertilizer producers become losses for farmers and consumers and vice versa. Hence, pricing policy should be designed in such a way that it optimizes the interests of everyone in the society – the producer, the trader, the farmer and, ultimately, the consumer.

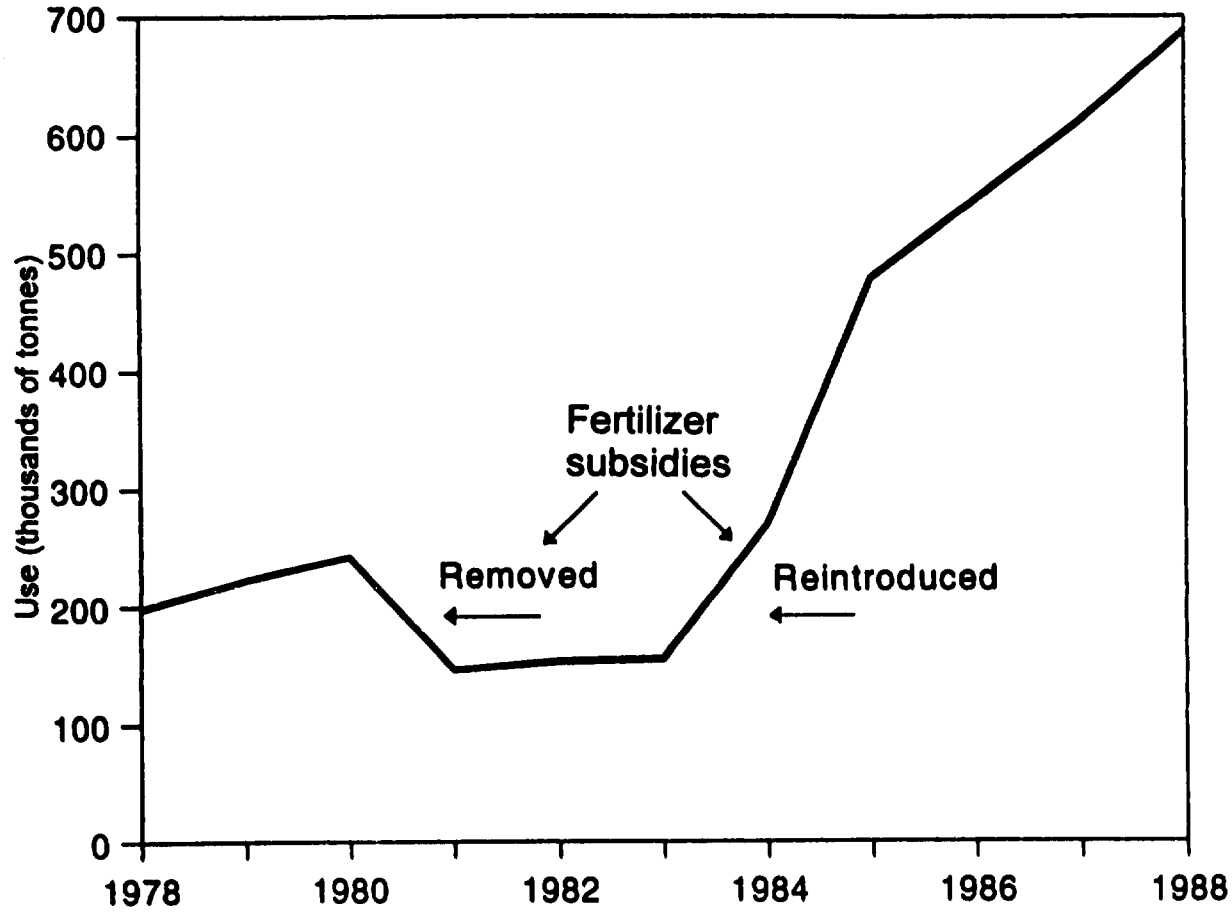
The multifaceted nature of the pricing policy has produced various price regimes in different developing countries [6]. Broadly, these price regimes vary from free market pricing (Thailand) to fully controlled pricing (Nigeria). In some developing countries, fertilizer prices are controlled at all levels, whereas in others they are controlled only at the factory gate or the port level. In countries where fertilizer prices are regulated, fertilizer subsidies have not been uncommon. China, India, Indonesia and Saudi Arabia still subsidize fertilizers, whereas Ghana, the Philippines, Thailand and Venezuela do not. With the implementation of structural adjustment programmes and market reforms, the number of countries subsidizing fertilizers decreased significantly between the early 1980s and the early 1990s.

In many countries, especially those where fertilizer supplies were not constrained, fertilizer subsidies have promoted rapid growth in fertilizer use and food production [7]. The most successful examples are China, India, Indonesia, Mexico, Nigeria, Saudi Arabia, Turkey and Venezuela. Although fertilizer subsidies have played an important role in promoting food security by increasing fertilizer use, they have at the same time created unsustainable fiscal burdens. For example, in India, fertilizer subsidies amounted to US$ 1.40 billion (Rs 44 billion), or 3 per cent of the national budget, in 1993/94. Consequently, many developing countries are phasing out subsidies. The experience of several countries suggests that the sudden and ad hoc removal of subsidies is not desirable because it may lead to a significant decline in fertilizer use, as happened in Venezuela (figure XIII). A proper sequencing and phasing scheme be developed and measures taken to prevent an adverse impact on the industry. Caution is needed in phasing out subsidies during a period of macroeconomic instability, especially during rapid devaluations. It may not be advisable to remove subsidies during rapid devaluations because this may drastically reduce fertilizer use, as happened in Ghana (figure XIV). Further analysis and research is needed to develop feasible and socially desirable policies.

In addition to phasing out subsidies, three other issues warrant discussion. These are the link between global and domestic prices, the determination of ex-factory prices and the introduction of free market pricing. With regard to the first issue, global fertilizer prices have a tendency to fluctuate widely in the short run (figure XV) and become unpredictable in the long run. In the short run, they reflect the supply-demand situation rather than the opportunity cost of producing fertilizers, and they decreased continuously in the 1980s. However, because of currency devaluation and subsidy removal, domestic prices have moved in the opposite direction (figure XVI). Until macroeconomic stability is restored and global prices become reflective of the true opportunity costs, it may not be advisable to link domestic prices with global prices.

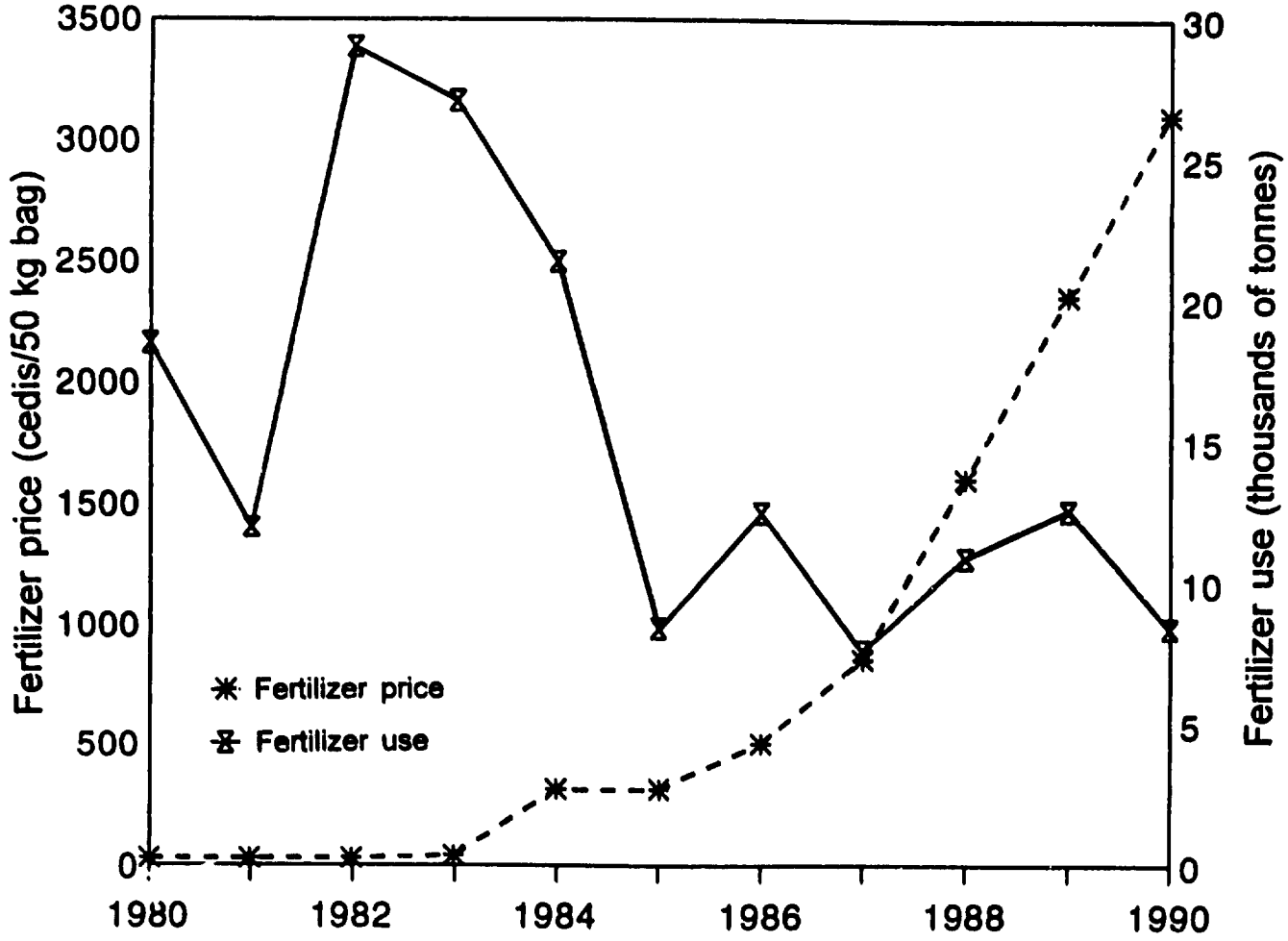
In determining the ex-factory prices under regulated price regimes, the developing countries have followed mostly cost-plus pricing schemes. Such a scheme does not provide incentives to improve efficiency because producers face guaranteed prices irrespective of the cost of production or the

Figure XIII. Fertilizer use in Venezuela, 1978-1988



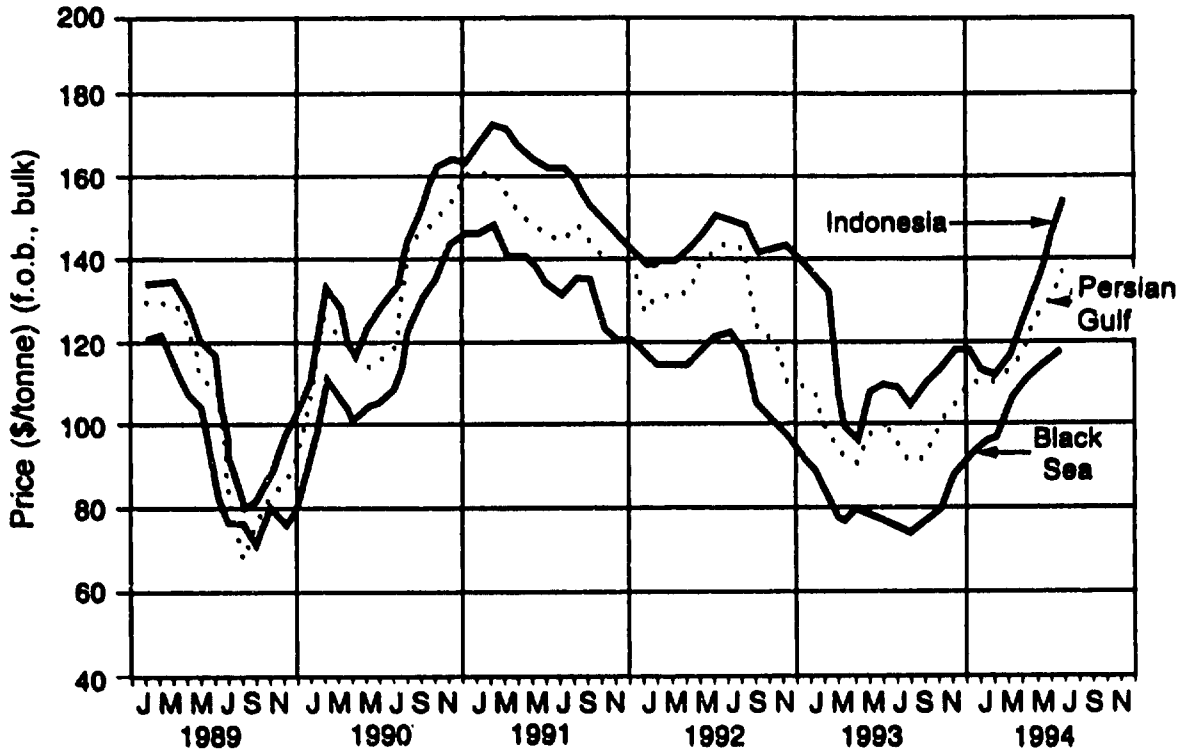
Source: B. L. Bumb, *Global Fertilizer Perspective, 1960-95: The Dynamics of Growth and Structural Change*, T-34 and T-35 (Muscle Shoals, Alabama, IFDC, 1989).

Figure XIV. Ghana: fertilizer use and price, 1980-1990



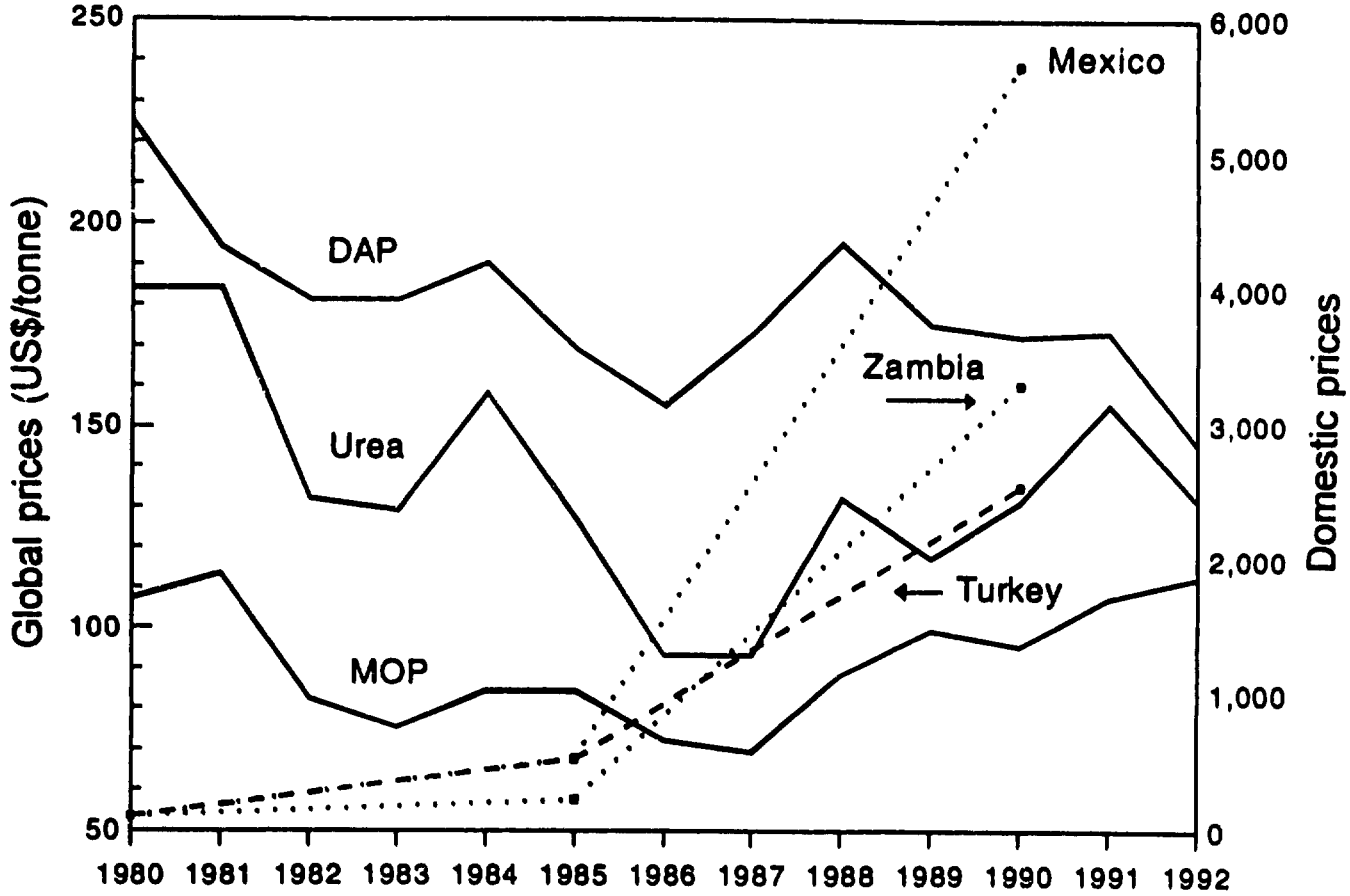
Source: B. L. Bumb and others, *Ghana: Policy Environment and Fertilizer Sector Development*, T-41 (Muscle Shoals, Alabama, IFDC, 1994).

Figure XV. World: fluctuations in monthly urea prices at various locations, 1989-1994



Source: FMB Consultants, Ltd., *Weekly Telefax Report*, 9 August 1994.

Figure XVI. Global and domestic fertilizer prices, 1980-1992



Source: ***Green Markets***, various issues, and FAO, ***Fertilizer Yearbook***, various issues.

Notes: Current global urea and diammonium phosphate (DAP) prices are f.o.b. Tampa, Florida, United States and MOP price is f.o.b. Vancouver, Canada. Current domestic prices are in index numbers, 1980=100.

efficiency of resource use. Indeed, such plants became heavy energy users and high-cost producers. Their insulation from foreign competition added to their inefficiency. In contrast, other countries, such as India, introduced an incentive-based pricing system, known as the retention price scheme (RPS). Under RPS, the cost of production is calculated by taking into account input norms based on technology, feedstock, vintage of the plant, capital investment and capacity utilization factors. Producers have an incentive to optimize plant operation through higher utilization of capacity and lower utilization of inputs. RPS has done well in India: it promoted investment, increased production and improved capacity utilization (table 12). Many plants in India operated above design capacity and have accumulated enough capital to invest in additional capacity in India or in other countries through joint ventures.

Table 12. India: progress in investment, production and capacity utilization, 1980/81 and 1991/92

Year	Investment (Rs billion)	Production (million tonnes)		Capacity utilization (%)	
		Nitrogen	Phosphate	Nitrogen	Phosphate
1980/81	41	2.16	0.84	53	65
1991/92	114 a	7.30	2.56	89	94

Source: FAI, *Fertilizer Statistics* (New Delhi, 1993).

a As of 10 January 1992.

Some people have mistakenly blamed the RPS for India's growing fiscal burden associated with fertilizer subsidies. However, it is not the fault of the RPS that India failed to increase farm-gate prices for about 10 years but allowed feedstock prices to increase regularly (table 13), widening the gap between ex-factory price and farm-gate price and causing an increase in subsidies. When a country is following a regulated price regime, it is crucial that policy be evaluated and monitored continuously and that the necessary adjustments made regularly.

Table 13. India: prices of fertilizer and feedstock, 1981/82 and 1991/92

Sales	1981/82	1991/92
Maximum price of fertilizers (Rs/tonne)		
Urea	2 350	2 350
DAP	3 600	3 600
MOP	1 300	1 300
Feedstock prices		
Naphtha, basic price (Rs/tonne)	1 371 a	2 726 b
Fuel oil, basic price (Rs/tonne)	1 039	1 815
Natural gas, landed cost (Rs/thousand m^3)		
Offshore and onshore	320-340	1 875
Along HBJ pipeline	-	2 800

Source: FAI, *Fertilizer Statistics* (New Delhi, 1993).

a Effective 11 July 1981.

b Effective 25 July 1991.

Lastly, should fertilizer prices be determined by free market forces? This question cannot be answered without considering socio-economic goals such as food security, regional development, environmental protection, size of the fertilizer market and the stage of fertilizer sector development. However, a few general observations are pertinent:

- If the market is sufficiently large and served by many sellers and if marketing skills and infrastructures are adequate, fertilizer prices can be allowed to be determined by free market forces at the retail and wholesale levels. If the market is small, as it is in many sub-Saharan African countries, and is served by only a few sellers, it may not be prudent to rely exclusively on free market forces because that approach could lead to high prices during the periods of shortages and in remote areas.

- A distinction should be made between fertilizer exporting countries and fertilizer importing countries. A free market system may work better in the former than in the latter because the latter generally face fertilizer shortages brought about by the macroeconomic factors mentioned above.

- Many developing countries have followed pan-territorial pricing policy to promote equity in fertilizer use and food production, especially among small farmers. In the initial stages, it may be desirable; however, when the market becomes large, it prevents the freedom of pricing that promotes competition and market efficiency. Improving the supply situation and infrastructural facilities should receive higher priority than pan-territorial pricing.

- Unless crop prices are liberalized, liberalizing fertilizer prices may not help in achieving socio-economic goals. Because many countries have controlled crop prices and kept them at low levels, they have failed to provide incentive for fertilizer use. For example, the price of fertilizers is much higher in Africa or Latin America than in Asia (table 14). In the world market, real fertilizer prices decreased between 1980 and 1986 and remained constant thereafter (figure XVII). However, real fertilizer prices increased in many developed countries. More attention should be paid to improving crop prices.

- In many countries, raw material prices remain controlled, and in some countries, they are very high. Unless these prices are liberalized, it may not help the industry to liberalize fertilizer prices. This, along with the volatility and unpredictability of global fertilizer prices, would suggest that fertilizer prices should be monitored at the ex-factory level.

Table 14. Prices of fertilizers paid by farmers, 1991/92
(United States dollars/tonne of product)

	Price		
Region/country	*Urea*	*DAP*	*MOP*
Africa			
Morocco	249	257	188
Senegal	-	365	-
Zambia	256	-	487
Zimbabwe	239	-	232

continued

Table 14 (*continued*)

Region/country	*Price*		
	Urea	*DAP*	*MOP*
Latin America			
Chile	345	261 b/	-
Colombia	155 a/	276 a/	97 a/
Uruguay	553 b/	297 b/	406 b/
Asia			
Bangladesh	126	140	136
India	118	181	66
Indonesia	110	-	141
Nepal	120	176	68
Pakistan	162	201	-

Source: Prices pertaining to countries in Africa and Latin America calculated from data in FAO. *Fertilizer Yearbook*, vol. 42. Prices pertaining to Asian countries are for December 1991 and were presented in Fertilizer Advisory, Development and Information Network for Asia and the Pacific (FADINAP), *FertilizerTrade Information*, monthly bulletin, March 1992.

a/ 1989/90.
b/ 1990/91.

C. Marketing of fertilizers

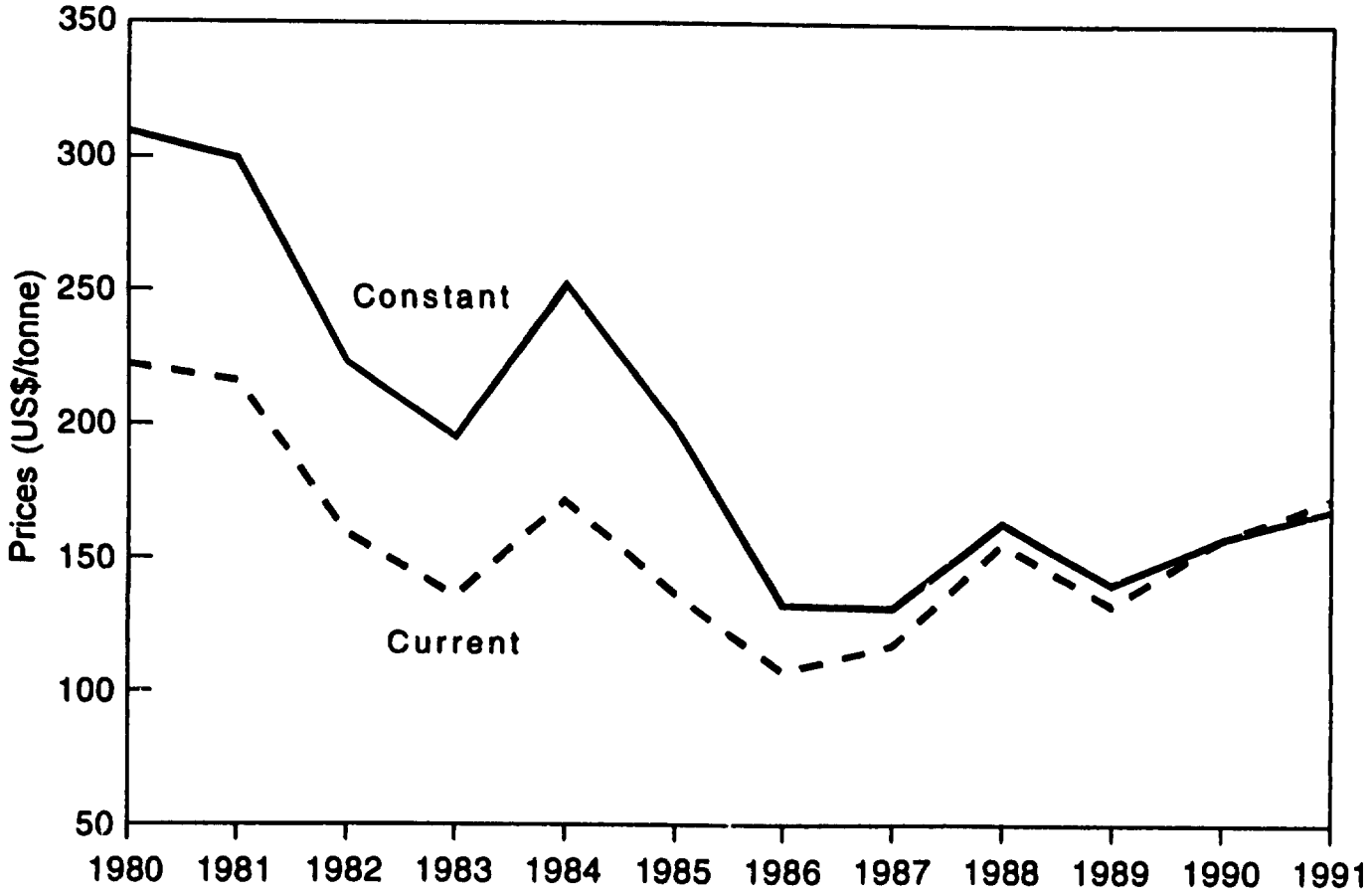
Efficient marketing and distribution arrangements are essential for improving the performance and promoting the growth of the fertilizer industry. It is through marketing channels that fertilizers reach the farmer on time, in the right quantity and quality and at the right price. Untimely and inadequate supplies of fertilizers have hampered the growth of the fertilizer industry in many countries. Because fertilizers have to be applied on time for maximum crop benefits, fertilizers delayed are basically fertilizers denied. This creates a disincentive for farmers to use fertilizers and reduces fertilizer demand, which in turn reduces growth in production.

Foreign exchange shortages leading to restricted fertilizer supplies, price regulation and subsidy administration have generally resulted in controlled fertilizer distribution systems in many developing countries. Parastatals and public sector agencies were created to distribute and import fertilizers. For example, P. T. Pupuk Sriwidjaja (PUSRI) in Indonesia and the Fertilizer Procurement and Distribution Division of the Ministry of Agriculture (FPDD) in Nigeria have a full monopoly on distributing fertilizers. Public agencies have performed at varying rates. In some countries, they were successful; in others, they became rent-seeking groups. In Nigeria, for example, a significant proportion of the fertilizer despatched from factories and ports is rarely delivered to farmers [8]. In addition, such organizations become a burden on scarce fiscal resources because their operations are subsidized. Before the fertilizer marketing system was reformed and privatized in Bangladesh, administrative expenses of the Bangladesh Agricultural Development Corporation accounted for the lion's share of fertilizer subsidies. After the reforms, not only were fertilizer subsidies eliminated but also the cost of fertilizers went down because of improvements in marketing efficiency.

The main issues in this area are, first, the roles of the public and private sectors in marketing fertilizers and, secondly, how to privatize the existing public sector agencies.

Empirical evidence suggests that public sector agencies or State-owned enterprises (SOEs) are less suited to efficient marketing because they operate under soft budget constraints, enjoy less

Figure XVII. World: current and constant urea price, 1980-1991



Source: World Bank, *Commodity Markets and Developing Countries: a World Bank Quarterly*, August 1994.

Notes: Price is bagged, f.o.b. northwestern Europe. Constant price is in 1990 US$, deflated by manufacturing unit value (MUV) index.

autonomy and authority and are subject to political interference. Further, they are guided more by the bureaucratic process (rules and regulations) than by the demands of business activities. The manager of a retail depot should have authority to decide prices and quantities, but the bureaucratic process, in which decision-making is generally top-down, does not allow this. Thus, public sector organizations ultimately perform mainly a distribution or allocation function. By contrast, marketing organizations in a competitive market system have authority to make decisions about product, price, promotion and place and are thereby able to improve efficiency and reduce the cost of distribution. In addition, the freedom of entry (that is, to enter the fertilizer business) and of exit (to leave it) ensures that the most efficient marketers will stay in business, because their operations are not subsidized. It is no wonder that the Sivaraman Committee recommended freedom of marketing for India in the mid-1960s and abolished the monopoly of cooperatives in fertilizer distribution.

While the private sector should play a dominant role in fertilizer marketing and distribution, the public sector still has an important role: it can ensure efficient functioning of the market by performing the regulatory functions. It should enact and implement legislation to provide high-quality products and to protect the environment. It should safeguard against collusion among sellers that could lead to a monopoly and it should develop monitoring mechanisms (information management systems) to prevent price increases. The government should also develop financial, physical and institutional infrastructures to promote smooth functioning and integration of the markets.

After identifying appropriate roles for the public and private sectors, attention should focus on how to move from a fully State-regulated/public monopoly system to a private, competitive market system, that is, on how to privatize the State-owned and -managed marketing and distribution systems. There are several possibilities, two of which merit special discussion because they deal with the speed with which public sector agencies should withdraw from marketing and distribution to make room for private sector dealers. One possibility is for the public agencies to withdraw rapidly from marketing and production activities so that the private sector can take over and develop free market systems. The other is for the government to withdraw gradually. Proponents of the latter approach say the development of management skills and institutional infrastructure is a slow and time-consuming process; if the government withdraws without developing such skills and infrastructure, the market may collapse and fertilizer use and production may decrease drastically and not recover for many years.

Many countries in eastern Europe, the former Soviet Union and Africa have followed the "big bang" approach without much success. Within 3-4 years, fertilizer use has decreased by between one third and two thirds because the private sector does not have the capacity and skills to replace the countrywide network of marketing channels, and farmers do not have an easy access to fertilizers. Of course, rapid devaluation and the removal of subsidies have also contributed to the collapse of the fertilizer market (figure XII). The rapid change did not allow enough time to acquire new skills and develop capacity.

A few countries, such as Bangladesh and China, have taken the gradualist approach to market reforms. In Bangladesh, IFDC was involved in developing the management skills and institutional infrastructures needed for the privatization of fertilizer marketing and distribution. It focused first on retail marketing and then on wholesale marketing, followed by the privatization of fertilizer imports. At each step, it developed the necessary cadre of entrepreneurs and created bottom-up pressures for reforms; however, it took nearly 13 years before imports could be privatized. Unlike in other countries, such as Ghana, Poland, the Russian Federation and Zambia, where fertilizer use decreased during the reform process, in Bangladesh fertilizer use increased at an annual rate of 8 per cent during the 1980-1993 period, even when subsidies were removed and fertilizer marketing and imports were

fully privatized. On the basis of this evidence, the gradualist approach to marketing reforms seems to be preferable.

D. Trade policy and regulation

The developing countries as a group are not self-sufficient in fertilizer production, although the degree of self-sufficiency varies among countries and regions. For example, Central America and West Asia are major exporters of nitrogen fertilizers, and North Africa is a major exporter of phosphate fertilizers. South America, South Asia, East Asia and sub-Saharan Africa are major importers of all three nutrients. At the country level, Indonesia, Iraq, Kuwait, Mexico, Saudi Arabia and Trinidad and Tobago are major nitrogen exporters and Jordan, Morocco and Tunisia are major phosphate exporters. Among developing countries, only Jordan has enough capacity to export potash fertilizers. Brazil, China, India, Malaysia and Turkey are the major importers.

In spite of their heavy dependence on imports, most developing countries have pursued a regulatory trade policy and allowed little freedom of trade in fertilizers. Recently, however, some (including Brazil, Kenya, Mexico, Turkey and Venezuela) have deregulated trade in all fertilizer products, and India has liberalized imports of phosphate and potash fertilizers.

The regulatory trade policies of the past were tied primarily to fixed exchange rate regimes and the limited allocation of foreign exchange and to the protection of domestic producers and farmers from the volatility of international fertilizer prices. To implement these policies, most developing country governments created parastatals such as the Minerals and Metals Trading Corporation (MMTC) in India, Sinochem in China and the National Agricultural Marketing Board (NAMBOARD) in Zambia. In other countries, such as Ghana and Nigeria, the responsibility for fertilizer imports remained with the Ministry of Agriculture.

In either mode, the responsible agency had a full monopoly on the import of fertilizers. Regulatory trade policies had advantages and disadvantages. On the positive side, countries could benefit from economies of scale by importing in bulk and could balance domestic production and imports. The policy makers were then able to promote the growth of the domestic fertilizer industry and to save foreign exchange through better price deals. The most successful country in this connection is China, whose Sinochem imports fertilizers at very favourable prices (table 15). India's MMTC was also very effective in getting good price deals. It did so by developing a suitable market intelligence system and then entering the market at the appropriate time.

Table 15. World: urea price at different locations, 1992
(United States dollars/tonne)

Location	*Type*	*Price*
Eastern Europe	f.o.b., bulk	98-108
Middle East	f.o.b., bulk	125-131
Caribbean a/	f.o.b., bulk	140-145
Indonesia	f.o.b., bulk	144-145
China b/	c & f	125-132

Source: *Fertilizer Week*, 16 November 1992.

a/ Granular urea.
b/ F.o.b. price negotiated by Sinochem at source was about $105-$109/tonne.

On the negative side, such arrangements have resulted in rent-seeking practices and in an untimely, inadequate and unsuitable supply of fertilizers in many countries, with the fertilizers having become a political commodity. When an agency is in a monopolistic position, it has less incentive to improve its performance. In addition, the cost of its inefficiency is borne by all the users, be they the farmers, traders or producers who are kept waiting for materials. This is perhaps the biggest disadvantage of such monopolistic arrangements.

In addition to being responsible for the disadvantages associated with monopolistic import arrangements, regulatory trade policies also affect the performance of the domestic industry. Because domestic producers are protected from foreign competition, they have little incentive to improve their efficiency. As a result, farmers must pay higher prices in a protected sellers' market, as happened in the Philippines in the early 1980s.

Although many countries controlled the import and export of fertilizers through quotas, only a few (Argentina, Thailand and a few others) imposed tariffs on fertilizer imports. Most countries wanted to promote fertilizer use through subsidies and other measures. Because fertilizers will remain a critical component of the food security strategy in many developing countries, a no-tariff policy should be continued in the future as well.

The performance and growth of the fertilizer industry will depend on a conducive trade policy that protects the interests of both producers and farmers. Two issues require detailed discussion: free trade in fertilizers and the phasing and sequencing of trade policy reforms.

Should developing countries embrace a free trade policy for fertilizers? A move in this direction would be desirable in the long run because it would improve production efficiency and widen the choice of products and technologies. The main advantage of such a policy would be a reduction in the subsidies that have protected inefficient factories. However, given the uncertainties of the international markets and the long gestation period needed for investing and building capacities, completely free trade in fertilizers would transmit the shocks and volatility of international markets to domestic fertilizer markets, introducing uncertainties into food production and perhaps endangering food security. Nevertheless, the complete regulation of trade and monopolistic arrangements for it would also be undesirable because it would perpetuate inefficiencies, fiscal burdens and rent-seeking behaviour. Accordingly, the developing countries should follow a middle path, i.e. a path of managed markets in which, through proper monitoring and evaluation of trade policy, gentle pressure – with breathing spaces – is placed on domestic producers to improve their efficiency so that they do not become a burden on the society. Under such a scheme, they would be given access to foreign exchange and foreign technology, including raw materials and improved maintenance and operating procedures to enhance their performance. If in spite of these incentives some companies are not able to improve their performance within 3-5 years, they should be liquidated.

The second issue deals with the phasing of trade policy reforms. Like marketing policy reforms, trade policy reforms can also be introduced suddenly or gradually. For the same reasons mentioned earlier, a gradual approach to policy reforms is preferable because the abrupt approach can destroy the industry by allowing the influx of unrealistically cheap fertilizers from abroad in the short run and forcing the country to pay higher prices in the long run. What happened with phosphate fertilizers in India in 1992 vividly illustrates the drawbacks of a sudden liberalization. This was a time when the depressed international price of DAP, coupled with the introduction of a single market rate of exchange, made domestic production uneconomic and led to the closure of DAP plants and nitrogen-phosphorus-potash (NPK) complex plants from April to June 1993. The plants reopened only after the Government announced a subsidy for indigenous material and the price of ammonia and

phosphoric acid dropped. Likewise, the sudden liberalization of fertilizer imports in Brazil, Mexico and Venezuela created problems for domestic industry.

E. Investment atmosphere and government incentives

The fertilizer industry is both capital-intensive and foreign-exchange-intensive. For a large-scale ammonia-urea plant, capital investment requirements vary between US$ 300 million and US$ 600 million, depending on location. The lower amount is for an additional plant at an existing location, the higher is for a greenfield project in a developing country. In many countries of Africa where infrastructures are underdeveloped, the needed investment may be even higher, although the cost of developing infrastructure should not be charged to a single project but should be treated as a social cost and charged to a social overhead development account in the national budget. Charging infrastructure cost to a single project puts the developing country fertilizer industry at a great disadvantage and makes it unrealistically uncompetitive.

Because of huge capital requirements, economies of scale and risks of investment, few private sector companies were willing to invest in fertilizer facilities in the 1960s and the early 1970s. Many developing countries were forced to take the lead in creating public sector organizations for such investing. For example, until the late 1980s, most fertilizer production in Brazil, Mexico, Pakistan, Turkey and Venezuela was controlled by SOEs. In Bangladesh, China, Egypt, Indonesia, Malaysia, Morocco, Nigeria, Saudi Arabia, Senegal and Tunisia, fertilizer production is still under public sector control. In India, it has been under all three sectors: public, private and cooperative, including joint ventures (table 16). India has also taken the lead in putting together joint ventures with other developing country fertilizer enterprises.

Table 16. India: production of nitrogen and phosphate by sector, 1981/82 and 1991/92
(Thousands of tonnes)

Year	*Public*	*Private*	*Cooperative*	*Total*
1981/82				
Nitrogen	1 626	1 080	438	3 144
Phosphate	296	402	250	948
1991/92				
Nitrogen	3 018	2 559	1 725	7 302
Phosphate	726	1 482	354	2 562

Source: FAI, *Fertilizer Statistics* (New Delhi, 1993).

In the past, the involvement of the SOEs was justified for several reasons:

- There was a strong need to promote fertilizer use to ensure food security, and in many countries food security translated into "fertilizer security". One way to ensure fertilizer security was to promote domestic production.

- Given the capital intensity and foreign exchange requirements, along with the volatility of global fertilizer prices, the private sector was not keen to invest in fertilizer production nor did it have the necessary capacity. The government was in a better position to take risks on investments.

- The pan-territorial pricing and subsidy policy pursued by many developing countries favoured SOEs because administering it was easy: it required only the transfer of resources in the budget.

- World Bank financing for fertilizer production was readily available, because the World Bank could lend funds only to national governments.

Government involvement in the fertilizer sector has been a mixed blessing. On the positive side, it provided the incentive to increase fertilizer production to meet the growing demand. As a result, fertilizer production increased over eightfold, from about 6 million tonnes in 1969/70 to 52 million tonnes in 1992/93. The ninefold increase in nitrogen production was even more spectacular: it went from less than 4 million tonnes to about 38 million tonnes. This was a result of the availability of natural gas in many developing countries, especially in Asia. However, for the reasons given earlier, sub-Saharan Africa did not experience such spectacular growth. It is unlikely that the private sector alone could have generated this type of growth in the 1970s and the early 1980s.

On the negative side, the overall performance of many was less satisfactory, for several reasons, including political interference; inadequate allocation of foreign exchange for spares, parts and raw materials; insufficient autonomy and authority for decision-making and implementation; and poor incentive structures, operation and management. Because many of the plants operated under soft budget constraints and weak financial discipline, they became a burden on the national budget, sustaining their operations through subsidies Management had little accountability and authority, so it paid little attention to improving plant operations to reduce cost and save energy. As a result, the plants became heavy energy users.

Nevertheless, many public sector plants in India, Indonesia, Mexico, Nigeria and Saudi Arabia have operated very well because management had the authority, autonomy and incentive to operate the plant on sound management principles. In this respect, many World Bank-financed plants score high because the Bank conditionality ensured competent management and adequate finances.

This discussion leads to two important issues: the role of ownership and management in operating fertilizer plants and the privatization of existing SOEs. Although ownership plays an important role by making the necessary investment, management determines the performance of the plant. Accordingly, some people suggest that as long as the SOEs are led by competent management teams and the government gives the management full autonomy and authority to operate the plant, makes it accountable, gives it proper incentives and refrains from political interference, there is no problem with State ownership; in developed countries also, ownership (shareholders) and management are kept separate. Thus, where the fertilizer sector is in its infancy and the private sector is not capable of taking risks and raising funds, as is the case in many African countries, fertilizer production facilities may continue to be owned by the government. However, the government must ensure that the plant is run by a competent management team. By contrast, where the fertilizer market is large, financial markets are well developed and the private sector has the ability and willingness to invest, the government should gradually withdraw from the fertilizer sector.

This leads to the issue of privatization. Should all fertilizer plants be privatized? The answer must be in the context of socio-economic goals, the nature of food and fertilizer security, the level of development of the fertilizer sector and the capacity of the private sector to take risks and make the investments needed to meet growing demand at reasonable prices. A few general observations are pertinent:

- If an SOE is economically viable and is performing well, there is little need to privatize it. If it is not performing well as a result of technical, financial or management constraints, then the

constraints should be removed and a competent management team put in place. If, even after such changes, the plant is still not viable, it should be liquidated, with suitable arrangements being made for deploying the existing labour force.

- Before full privatization is pursued, the option of corporatization should be explored: all fertilizer SOEs would be formed into a corporation that would manage the plants in the most efficient way [9]. This step would reduce political interference and put plants as a whole under hard budgetary constraints.

- The public sector should be allowed to wither naturally througn marketization. That is, new investments should be promoted in the private sector, and public sector plants should be allowed to reach their effective life and be gradually exposed to market competition, as China has done. Old, obsolete and inefficient plants will be phased out, reducing the size of the public sector over time.

- If, for fiscal and other reasons, privatization is the only desirable option, then it should be pursued gradually and with adequate preparation and improvements so that fertilizer supplies do not collapse. The ultimate goal is fertilizer security, and privatization is only an instrument to achieve that goal, not a goal *per se*.

Since, the private sector will play an increasingly important role in owning and managing fertilizer production facilities, developing countries should create an enabling environment for its involvement. This will require actions in several areas:

- The government should provide adequate foreign exchange on a timely basis so that the investor can have access to the best technology and equipment needed for fertilizer production.

- If both public sector and private sector plants are involved in fertilizer production, then the government should treat them fairly by creating a level playing field. That is, producers in both sectors should have access to the same facilities and privileges.

- To encourage investments, the government should provide incentives through tax holidays, investment credits and tax rebates.

- The government should ensure availability of feedstocks (natural gas and power) and other raw materials.

- It should manage its trade policy in a way that does not create unnecessary problems for the industry, as happened in India. Liberalization should be gradual so that the domestic industry can prepare itself to face the competition.

- The government should promote fair competition among producers by preventing producers from colluding through antitrust and quality control laws.

- The government should not impose tariffs and taxes on imported fertilizer raw materials and parts.

- It should not control fertilizer prices and should allow fertilizer producers to develop their markets, because both price controls and market controls hamper producer efficiency. However, if it is essential to control prices and movements, every effort should be made to guarantee adequate incentives for production.

- Since the fertilizer industry is a capital-intensive industry, it is crucial for adequate funds to be made available for investment and renovation. Where capital markets are not fully developed and the government controls most of the financial institutions, every effort should be made to ensure adequate funds.

- The government should provide support for research and development and technology transfer so that the industry can benefit from advanced technologies.

F. Technological base

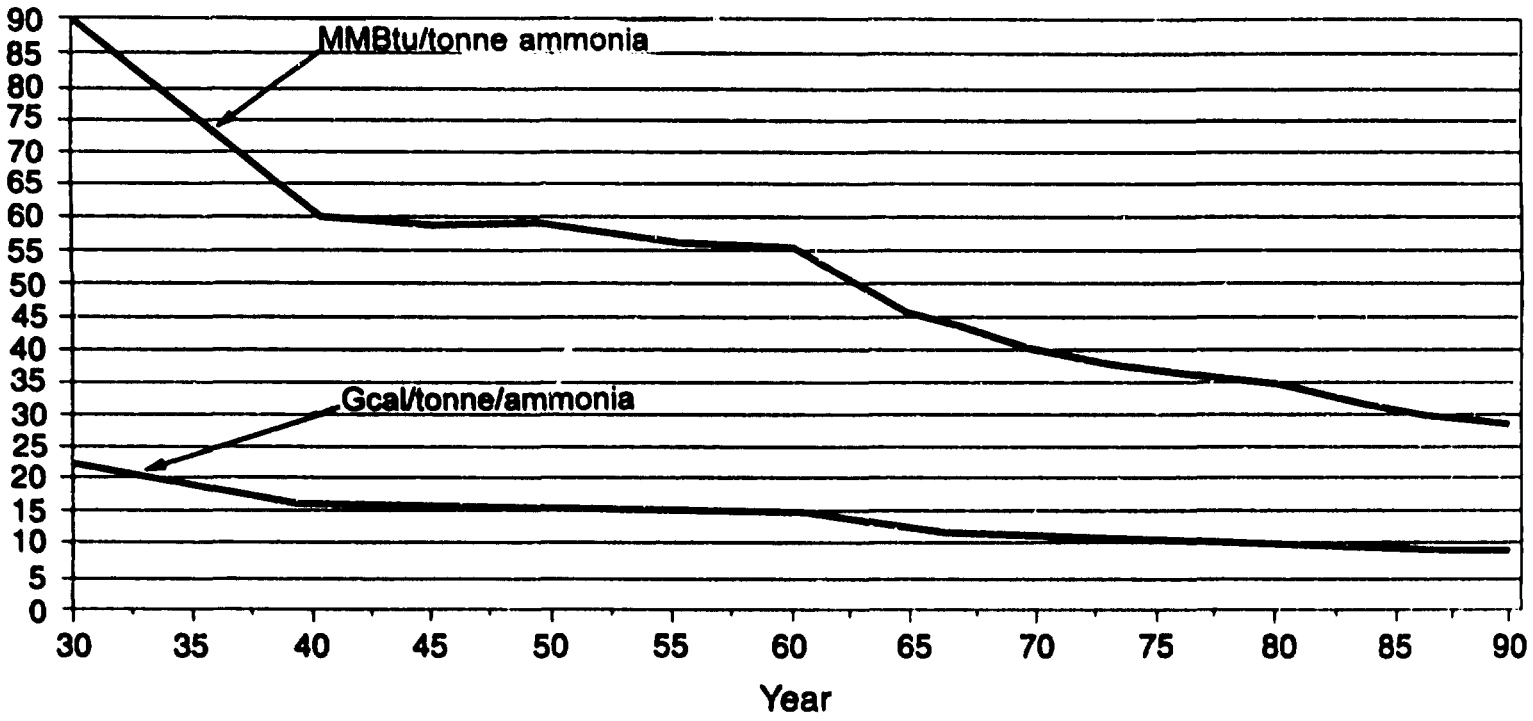
The performance and growth of the fertilizer industry depend on the technological base of the industry. If the fertilizer plants use modern technologies, they usually perform better in terms of production cost, energy use and environmental protection. If they use old technologies, their performance is usually unsatisfactory. Many fertilizer plants built in the 1950s and the 1960s in the former Soviet Union are high energy-users and polluters. Likewise, small ammonium bicarbonate plants in China are also energy-inefficient. By contrast, most plants built in the late 1970s and the early 1980s in North America are highly energy-efficient and environmentally safe. In modern ammonia plants, energy use has decreased from about 40 million Btu in the early 1970s to 28-30 million in the late 1980s (figure XVIII). Many fertilizer plants built in the 1980s in developing countries such as China, India, Indonesia, Mexico, Nigeria and Saudi Arabia embody the latest technology.

In the developing countries, a large proportion of ammonia capacity is not very old (table 17). However, the small plants in China that account for nearly half of the country's nitrogen capacity, coal-based plants in India, and small plants in other countries cannot be considered technologically sound. Since natural-gas-based large-scale ammonia plants are the most efficient in terms of energy use, natural-gas-rich regions became major exporters of nitrogen fertilizers in the 1980s and the lack of natural gas in western Europe limited the size of the industry there significantly. In the past, the use of centrifugal compressors to reduce energy use in ammonia production required that the plant be large, at least 600 tonnes/day. Now, several new processes, including that of Imperial Chemical Industries (ICI), leading concept ammonia (LCA), allow energy savings even in medium-size (300 tonnes/day) plants. These can help in converting some high-energy-use plants into low-energy-use plants as well as building plants where the fertilizer market is small, e.g. in sub-Saharan Africa.

The technology embodied in the feedstock, the ammonia production process, and the vintage of the plant causes the operating efficiency of fertilizer plants in many developing countries to be rather low. In contrast to 95-100 per cent capacity utilization in North America and western Europe, capacity utilization in many developing countries averages 70-80 per cent. Several factors cause this relatively poor performance, but inadequate maintenance has been one of the most important. As poor maintenance eventually results in poor performance, improving it through adequate financial, managerial and technical support must receive priority attention. In this respect, the autonomy and authority of public sector management cannot be overstressed. Many developing countries may need considerable additional resources to be able to improve the technical efficiency of their fertilizer industry.

Another area that affects the technology base of the fertilizer industry is the choice of fertilizer products. In many countries, such as China, Ghana and Jamaica, low-analysis products are not uncommon. A move towards high-analysis products should be encouraged, as was done in China and India, where most of the additional capacity created in the 1980s was for urea and DAP. This is not to suggest, however, that agronomic requirements such as sulphur-carrying single superphosphate (SSP) should be sacrificed.

Figure XVIII. Specific energy consumption for ammonia production, 1930-1990



Source: K. M. Constant and W. F. Sheldrick, *World Nitrogen Survey*, Technical paper 174 (Washington, D.C., World Bank, 1992).

Table 17. Developing countries: ammonia capacity by start-up year, 1993

	Asia			*Africa*		*Latin America*		
Start-up/Year	*East a/*	*South*	*West b/*	*North*	*Sub-Saharan*	*Central*	*South*	*Total developing countries*
Before 1980	5 486	5 098	1 872	535	63	801	1 188	15 403
1980	231	760	0	272	0	0	0	1 263
1981	0	244	272	326	0	638	0	1 479
1982	0	1 202	0	272	72	638	571	2 755
1983	720	107	584	0	0	0	0	1 411
1984	680	98	272	0	0	0	0	1 050
1985	272	779	339	272	0	0	0	1 662
1986	272	732	0	0	0	0	0	1 004
1987	272	435	732	272	272	0	0	1 983
1988	666	1 097	272	0	0	369	0	2 404
1989	388	0	272	0	0	0	0	660
1990	518	163	544	0	0	0	50	1 275
1991	411	313	42	272	0	53	0	1 091
1992	540	344	28	0	0	0	0	912
1993	1 054	1 066	707	109	0	53	41	3 030
NA c/	14 506	193	0	272	0	1 657	343	16 971
Total	26 016	12 629	5 936	2 602	407	4 209	2 193	53 991

Source: IFDC, Global database.

a/ Excluding Japan.
b/ Excluding Israel.
c/ Capacity for which information about the start-up year is not available.

Technology policy plays an important role in promoting an efficient technological base for the industry. To promote growth of the domestic industry, many countries limit the technology choices, sometimes for no apparent reason. For example, in the early 1980s, India restricted its technology options for several large-scale plants to one technology producer, which was not necessarily the most efficient one. Such policy decisions not only resulted in high construction costs and energy consumption but also deprived India of an opportunity to upgrade its technical capabilities in this area and borrow international funds at concessional rates. Ideally, the developing countries should follow a pragmatic, open-door policy and should use international competitive bidding for technology selection.

G. Utilization of indigenous raw materials

The availability of indigenous raw materials plays an important role in promoting growth in the fertilizer industry. Easy access to natural gas has caused the industry to grow rapidly in many developing countries, including China, Egypt, India, Indonesia, Mexico, Saudi Arabia, Turkey, Venezuela and other West Asian countries. Likewise, the availability of abundant phosphate rock has made Morocco a world leader in phosphate fertilizers. On the other hand, limited availability of potash ores has deprived many developing countries of a potash industry. Without access to raw materials, no country should attempt to develop a fertilizer industry, because it cannot be sustained based exclusively on imported raw materials.

Although indigenous raw materials are necessary for the growth of the fertilizer industry, they are not sufficient in themselves. Many countries in sub-Saharan Africa are rich in phosphate rock (figure XIX), but low international prices and inadequate infrastructure and technical skills make the development of such resources very costly [10]. However, where foreign exchange shortages constrain the import of fertilizers, the development of phosphate rock for direct application should receive greater attention. In many African countries, subsidized fertilizers received from donors as grants have prevented the development of these resources. IFDC research in many African countries indicates that direct application of phosphate rock or of modified products such as partially acidulated phosphate rock and compacted materials (phosphate rock with triple superphosphate (TSP)) can supply much-needed phosphate for African soils [11]. However, in developing these resources, conducive policy and adequate donor support will be indispensable.

While many developing countries, such as Argentina, Chile, Mozambique, Nigeria and the United Republic of Tanzania, have natural gas, low international prices and excess supply do not now justify new investment in new fertilizer facilities. However, if excess supply is eliminated, prices will recover to remunerative levels and will justify new investment. In any case, to avoid fertilizer shortages and to ensure adequate fertilizer supplies in the first decade of the twenty-first century, the developing countries should invest in fertilizer production, because very little investment is likely to occur in the developed countries, at least in the 1990s.

H. Physical and human infrastructure

Because products must reach millions of farmers scattered all over a country and all over the developing world, the fertilizer industry requires well-developed physical and human infrastructures, which many developing countries do not have. On the physical side, the lack of warehousing, storage and transportation networks hampers the performance of the sector and in many African countries leads to high prices for farmers; indeed, in several countries, the cost of internal distribution exceeds the border price. Lack of roads, railways and power facilities adds to the investment costs, making such investments unattractive. In a greenfield project in a developing country, infrastructure may

Figure XIX. Economic and potentially economic phosphate deposits of the world

Source: S. J. Van Kauwenbergh, "Future changes in the world supply of phosphate rock and potential impact on the global manufacture of fertilizers", Paper presented at the American Chemical Society Meeting, Washington, D.C., 21-26 August 1994.

account for 30-40 per cent of total project cost. This important policy issue should be given greater priority by developing country governments, especially in sub-Saharan Africa.

In addition to transportation and distribution networks, developing countries should also pay particular attention to developing storage and warehousing facilities, especially at the farm level. Many farmers store their fertilizers in the open. In China, the industry incurs considerable distribution losses due to inadequate facilities for storage and warehousing at all levels. Because fertilizer is an expensive commodity, losses should be prevented by developing adequate storage facilities.

Lack of skilled manpower, which is needed in all domains (production, distribution, import, use and construction of plants), is another constraint on the performance of the fertilizer industry. In many countries, especially in Africa, this lack has prevented growth in fertilizer use, marketing, import and production. In many developing countries, the lack of trained personnel has reduced the capacity utilization of existing plants and caused delays in the construction of new plants. Keeping plant management abreast of changing technologies requires adequate and timely investment in human capital.

Many developing countries that once had public sector monopolies in marketing and distribution are now moving towards privatization of fertilizer sector operations. Unfortunately, many producers are ill-prepared to market their products because, in the past, the government did everything for them. Now they have to face competition not only from domestic producers but also from foreign producers and traders. This situation requires large investments to train producers and traders in fertilizer marketing and distribution. IFDC has been involved in such training in Albania, Bangladesh and Romania, as well as at its headquarters. FAI also organizes training programmes in fertilizer production, marketing and use that attract participants from many countries. The developing countries should take advantage of the help that such institutions can give in preparing cadres with the necessary skills for strengthening private sector involvement in the fertilizer sector.

III. Inter-country cooperation

The technologies and resources needed for the development and growth of the fertilizer industry are unevenly distributed among countries. Some countries have the raw materials, such as natural gas and phosphate rock, to produce fertilizers but lack the financial and human resources to develop them. Other countries have technologies but not the raw materials. While many developing countries are experiencing growth in their fertilizer markets, the developed countries, despite having the technologies and capacities to produce fertilizers, are experiencing saturation in theirs. To optimize the use of global resources and to better balance demand and supply, there should be greater cooperation between developed and developing countries and among developing countries.

A. Cooperation between developed and developing countries

It was indicated earlier that fertilizer surpluses will be concentrated in the developed countries, whereas the deficits will be in the developing countries, especially those of East Asia, South Asia, South America and sub-Saharan Africa. In addition to having surplus production capacity and raw materials in North America and the former Soviet Union, the developed countries also have technologies and capital to invest in promising and growing markets. Kellogg, Braun, ICI, Topsoe, Udhe, Snamprogetti, Shell and Toyo are some of the well-known providers of fertilizer technology. ICI, IMC, Agrico and Norsk-Hydro are among the large producers in the fertilizer world. The experience, expertise and capital of these companies can be used to develop joint ventures between developed and developing countries, as was done by Kellogg in Nigeria; Sinochem (of China) in the United States; U.S. Steel, Amoco and IMC in India; and Norsk-Hydro in Trinidad. The main advantage of such joint ventures is that they give both countries a secure market; additionally, the developing countries can get the necessary technology and foreign exchange. However, such cooperation requires support from the country governments, especially those of the developing countries. The developing country governments should also create an enabling environment by providing infrastructures and incentives and minimizing unnecessary bureaucratic hurdles, trade regulations and tariffs. The most thorny issues relate to foreign exchange earnings and repatriation, feedstock supplies, ownership and product pricing. To attract investment and technologies, the developing countries should provide freedom in these areas, but foreign investors should not take an unrealistically optimistic approach, as was done by the producer consortium led by the Bechtel Corporation of the United States in the mid-1960s [12]. However, as a result of the GATT negotiations, the North American Free Trade Agreement, and the globalization of markets that followed the demise of communism in the former centrally planned economies, the atmosphere for foreign investment is improving in many developing countries.

B. Cooperation among developing countries

In the last 20 years, many developing countries have attained considerable technical capability, know-how and markets for fertilizers. Several countries in Africa, Central America and West Asia are rich in raw materials and others in East and South Asia and South America have a deficit in fertilizers notwithstanding their highly sophisticated fertilizer industry structures. Joint ventures between countries in these two groups could be of mutual benefit. The joint ventures between India

and Senegal, Pakistan and Jordan, and India and Oman are some examples of such cooperation. The first of these offers some useful lessons about such arrangements.

In 1982, the Government of India and the Government of Senegal agreed to develop a phosphate fertilizer facility in Senegal. Because India was looking for an assured supply of phosphate fertilizers to meet its growing demand and Senegal had phosphate rock and wanted to use this resource to earn foreign exchange, the deal was to the advantage of both. In the event, the Government of India and the two Indian companies, Indian Farmers Fertilizer Cooperative Limited (IFFCO) and Southern Petrochemical Industries Corporation Ltd. (SPIC), contributed about 18 per cent to the equity of the Senegalese company, Industries chimique du Sénégal (ICS). India agreed to buy all ICS phosphoric acid production at the higher of two prices, the f.o.b. international price or the cost of production. However, if the cost of production was used, ICS was to reimburse India through a rebate on future purchases when international prices improved. Although the joint venture gave India a secure supply of phosphoric acid, the pricing agreement did not work to its advantage because delays in completing the plant, technical problems after start-up leading to low capacity utilization and the fall in global prices resulted in a higher cost of production. ICS was not able to pay a dividend on its equity and owed about $12 million in rebates to India in May 1994.

Several lessons can be learned from this experience. On the positive side, the joint venture helped India by providing a secure supply of phosphoric acid, stabilizing global prices and reducing the subsidy burden and foreign exchange costs. On the negative side, India had to pay for the inefficiency of the plant operations. In the future, better agreements should be worked out to safeguard the interests of both parties.

It is clear from this experience that because product pricing remains the most crucial element in such ventures, it deserves more attention. Governments should also liberalize foreign exchange transactions and other regulations.

The supply and price of raw materials is another area that needs careful scrutiny. Like product prices, feedstock prices can also change considerably over the life of the project. Issues connected with the transfer of foreign exchange should also be clearly defined, especially for countries that have higher inflation rates. India's joint venture with Oman is considering these issues.

IV. Public policy measures for environmental protection

A. Environmental protection and the fertilizer industry

The significant contribution of the fertilizer industry to food security in developed and developing countries has recently been eclipsed by environmental concerns associated with fertilizer use and production. Nitrate leaching, eutrophication, cadmium uptake by plants and its potential impact on human health, and the disposal of phosphogypsum are among these concerns. The disposal of effluents such as waste products and waste water and of gases such as nitrous oxides and carbon dioxide, which contribute to greenhouse gases are other concerns.

Before discussing public policy measures to deal with these environmental concerns, it would be useful to develop a classification for the different impacts. Broadly, they can be divided into two groups, namely, impacts associated with fertilizer use and impacts associated with fertilizer production. Under each group, impacts can be classified as to the nature of the pollution source, namely, point pollution and non-point pollution. Most of the pollutants associated with fertilizer production, e.g. phosphogypsum, fluorine, sulphur dioxide, oxides of nitrogen and waste water, are of the point pollution type. Because they occur near the factory, they can easily be controlled. On the other hand, nitrate leaching and eutrophication, which are associated with fertilizer use, are of the non-point type. In this type of pollution, the polluter is separated from the polluted objects, so the pollution is hard to control by punitive measures. For example, when fertilizers are carried away by water runoffs or soil erosion and contaminate lakes and rivers, causing eutrophication, it is difficult to find out who created that pollution. In such cases the "polluter pays" principle cannot be applied. Likewise, groundwater can become contaminated from organic (legumes/animal manures), inorganic (fertilizers) or natural (mineralization of soil nitrogen) sources of nitrogen as well as from sewage sludge, septic tank drainage or industrial waste, so it is difficult to implicate a single source, say fertilizers, without adequate analysis and measurements.

B. Environmental concerns associated with fertilizer use

Nitrate leaching, eutrophication, greenhouse gases and cadmium uptake are major environmental concerns associated with fertilizer use.

1. Nitrate leaching

When the nitrogen applied and available in the soil is not eventually used up by a plant, it can leach into the groundwater as nitrate or escape to the atmosphere in the form of nitrous oxide; it can also enter surface water. High levels of nitrate can be hazardous to human health, causing "blue baby" syndrome. The regulations in the United States and the European Union suggest that nitrate levels of 45-50 milligrams per litre of water are safe for humans. Because fertilizer use is still low in many developing countries, the contamination of drinking water by nitrogen fertilizers has not become a problem. Most of the nitrates in waters have been associated with non-fertilizer sources, such as industrial waste, sewage sludge and septic tank drainage. However, where fertilizer application rates are high, environmental monitoring for nitrate levels in the ground- and surface water should be

introduced. Improved fertilizer management practices should be encouraged to prevent nitrate leaching.

2. Eutrophication

When phosphate and other fertilizers are carried away by runoff and soil erosion to lakes, ponds and other water bodies, they promote the growth of aggressive algae and other plants, leading to an inadequate supply of oxygen and the destruction of beneficial plants, fish and other aquatic life. Eutrophication can be controlled by the proper management of fertilizers on the farm, including measures such as the planting of barrier vegetation. Farmers in developing countries need to be made aware of this problem.

3. Cadmium

Cadmium intake is hazardous to human health. The guidelines of the World Health Organization (WHO) indicate that a cadmium intake of 1 μg/kg body weight per day is not harmful to humans. In many European countries, where fertilizer use is high, cadmium intakes are very low [13].

In phosphate fertilizers, cadmium comes from the phosphate rock. Many rocks have high levels of cadmium (table 18), but the mechanisms by which it is transmitted from the fertilizers (direct application of phosphate rock or finished fertilizers) to the soil, to plants and to humans are not that clear. At the Rothamsted Station, even after 100 years' use of phosphate fertilizers, an insignificant amount of cadmium was discovered in grains; tobacco leaves, by contrast, can pick up a considerable amount of cadmium from soils. Industrial pollution and detergents also raise cadmium levels in the soil.

Table 18. Phosphorus and cadmium in phosphate rock a/

		Cadmium	
Source	*Phosphorus (%)*	*mg/kg rock*	*mg/kg phosphorus*
Volcanic rock			
Kola, Russian Federation	17.2	0.15	0.9
Palfos, South Africa	17.2	0.15	0.9
Sedimentary rock			
Bou Craa, Morocco	15.9	35	220
Togo	15.7	55	350
Youssoufia, Morocco	14.6	40	274
Jordan	14.6	5	34
North Carolina, United States	14.4	40	278
Florida, United States	14.4	8	56
Negev, Israel	14.2	20	140
Khouribga, Morocco	14.2	16	113
Khneifiss, Syrian Arab Republic	13.9	6	43
Gafsa, Tunisia	13.2	50	380

Source: O. C. Böckman et al., *Agriculture and Fertilizer: Fertilizers in Perspective* (Oslo, Norsk-Hydro, 1990).

a/ These are typical values but can vary considerably between deposits and within a deposit. For example, in Tunisia, there are deposits containing only 10 mg Cd/kg rock.

As part of its ongoing efforts in this area, IFDC reviewed soil samples and plant tissues from some developing countries where phosphate rock has been used for a long time and found a very low cadmium content [14], but more research is needed. Because cadmium regulations have an adverse impact on the fertilizer industry and the macroeconomies of many developing countries, especially in North and West Africa and West Asia, adequate research must be funded to develop sound guidelines.

4. Greenhouse gases

Nitrous oxide and methane are important sources of greenhouse gases associated with fertilizer use, especially in paddy fields. Although the issue of global warming is debatable, the contribution of fertilizer use to global warming is likely to be small [14], [15]. Research rather than regulation is needed in this area.

C. Environmental concerns associated with fertilizer production

The environmental concerns associated with fertilizer production are few and well understood; technologies to minimize their adverse impacts are in most cases well known. The main issue here pertains to the costs of installing the technologies and who should pay those costs. Before that question is addressed, the main pollutants associated with fertilizer production are summarized (they mostly relate to various effluents, including phosphogypsum).

1. Pollutants associated with nitrogen production

The discharge of the various gaseous, liquid and solid pollutants associated with ammonia and urea production can affect the community and the atmosphere. For example, the discharge of waste water from ammonia plants can raise nitrate levels, and eliminating nitrate in the discharged water can be costly. In addition, the nitric oxides and carbon dioxide can contribute to the greenhouse gases. However, with proper technologies and regulation, emissions and pollutants can be minimized [16].

2. Pollutants associated with phosphate production

Phosphogypsum is a by-product in the production of phosphoric acid. For every tonne of phosphoric acid produced, 4-5 tonnes of phosphogypsum are produced. Because it contains radium, phosphogypsum can emit radon (radioactive gas), which is hazardous to both humans and animals. To safeguard against the harmful effects, it should be deposited in covered stacks or ponds. Although it can be used for agricultural, industrial and road-building purposes, economic considerations do not justify such uses on a large scale [13], [17]. To dispose of it in an environmentally friendly way could cost anywhere from $5 to $80 per tonne in the United States in 1988/89. Land reclamation and process water treatment could add as much as $70 per tonne (table 19). Treating these pollutants in 1988/89 could have increased the cost of DAP production by $34-$175 per tonne phosphate in the United States (table 20). Although these cost estimates pertain to the United States, they are indicative of the cost implications of environmental measures in other countries.

Table 19. United States: cost implications of environmental compliance, 1988/89

Treatment	*Incremental cost (US$/tonne phosphate)*
Land reclamation	1-5
Phosphogypsum disposal	5-80
Process water treatment	20-70

Source: J. J. Schultz, D. I. Gregory and O. P. Engelstad. "Phosphate fertilizers and the environment: a discussion paper", P-16. IFDC, 1992.

Table 20. United States: cost of treating pollutants generated by the phosphate industry, 1988/89

Product	*Cost (US$/tonne phosphate)*
Phosphate rock	4.0
SSP	4.0
PAPR-SA	4.0
NPK (Odda process)	4.0
NPK (mixed acid process)	19-90
PAPR-PA	19-90
TSP	24-124
MAP	34-175
DAP	34-175

Source: J. J. Schultz, D. I. Gregory and O. P. Engelstad. "Phosphate fertilizers and the environment: a discussion paper", P-16. IFDC, 1992.

V. Summary and conclusion

A. The need for fertilizers

The world population increased from 3.0 billion in 1960 to 5.5 billion in 1993 and is projected to reach 8.5 billion in 2025. Over 93 per cent of the increase in population is expected to occur in the developing countries. To feed this population, global food production must double by 2025. With limited cultivable land, increased production will have to come from increased crop yields; for this, fertilizers, along with other inputs, are crucial. Fertilizers are also important in replenishing the nutrients whose removal leads to resource degradation. Thus, increased fertilizer use is essential for two reasons: to promote food security and to protect the environment in developing countries.

B. Trends in fertilizer use, production and trade

Global fertilizer use increased from 27 million tonnes in 1959/60 to 146 million tonnes in 1988/89 and decreased continuously thereafter to 126 million tonnes in 1992/93. A steep fall in fertilizer use in the former centrally planned economies is largely responsible for the decline. In the developing countries, fertilizer use increased from 3 million tonnes in 1959/60 to 68 million tonnes in 1992/93. Although developed countries registered a significant fall in fertilizer use after 1988/89, developing countries continued to experience growth. Consequently, their share of global fertilizer use increased from 10 per cent in 1959/60 to 54 per cent in 1992/93.

Fertilizer use increased in all three regions, namely, Asia, Latin America and Africa, with Asia registering the largest absolute and relative increases. In 1992/93, Asia consumed 57 million tonnes of nutrients and accounted for 84 per cent of developing country fertilizer use. Asia also became a dominant region in the global context by accounting for 44 per cent of global fertilizer use. Fertilizer use in the developing countries is dominated by nitrogen use. In 1992/93, nitrogen use accounted for 65 per cent of the total. This is leading to nutrient imbalances. To restore a proper balance, phosphate and potash use should be increased through appropriate change in policies and programmes.

Global fertilizer production increased from 28 million tonnes in 1959/60 to 158 million tonnes in 1988/89. Thereafter, the decline in fertilizer use induced a decline in production: between 1988/89 and 1992/93, fertilizer production decreased by 20 million tonnes. In the developing countries, fertilizer production continued to increase to reach 52 million tonnes in 1992/93. Asia accounted for 83 per cent of the total fertilizer production in developing countries. Because of limited raw materials for phosphate and potash production, Asia's share of global fertilizer production is smaller than its share of fertilizer use. Like nitrogen use, nitrogen production also dominates fertilizer production in the developing countries. In 1992/93, nitrogen production accounted for 70 per cent of total production. Given the abundant supply of natural gas and capital in West Asia, nitrogen production will continue to dominate fertilizer production in the future as well.

Fertilizer trade also increased. In spite of the increase in production, many developing countries, including China and India, have to depend on imports to meet the domestic requirements. Net imports increased from 1.3 million tonnes in 1959/60 to 17.4 million tonnes in 1992/93, accounting for about one fourth of fertilizer consumption. Indonesia, Iraq, Jordan, Mexico, Morocco, Saudi Arabia and

Venezuela have become major exporters of fertilizers, whereas Brazil, China, Egypt, India, Thailand and Turkey are some of the major importers.

C. Outlook

Projections of future demand suggest that fertilizer use in the developing countries will increase from 68 million tonnes in 1992/93 to 115.2 million tonnes in 2010. As very little growth in capacity is expected in the developed countries, the developing countries should plan to supply the needed fertilizers through domestic production and/or imports. In this respect, the developing countries should consider developing joint ventures with developed countries and among themselves.

D. Factors affecting the growth of the fertilizer industry

Several factors affect the growth of the fertilizer industry in the developing countries. These factors may be divided into two broad groups, namely, policy-related and non-policy factors. Policy-related factors include macroeconomic, environmental, pricing, marketing, investment, trade and organizational policies, whereas non-policy factors are the technological base, physical and human infrastructure, size of the market and availability of feedstocks. Although factors in both groups influence the performance and growth of the fertilizer industry, evidence over the last two decades shows that a conducive and stable policy environment plays a more important role, with countries that created a sound policy environment having experienced more rapid growth than countries that did not. The contrast in the growth performance of South Asia and South America in the 1980s is mostly attributable to the policy environment. Because of the stable and conducive policy environment in South Asia, fertilizer use there increased from 7 million tonnes in 1980/81 to 16 million tonnes in 1990/91, whereas an unstable and nonconducive policy environment in South America caused fertilizer use to fluctuate considerably without any increase during the 1981-1991 period.

E. Conclusion

Foreign exchange shortages, exchange rate depreciation, non-incentive crop and fertilizer prices, ad hoc removal of subsidies and privatization, and inadequate credit support are some of the policy-related factors that hampered the growth of the fertilizer industry. Inefficient organizational arrangements and inadequate physical and human infrastructures — a result of inappropriate policy environments — also affected fertilizer sector operations. Improving policies and programmes in these areas will contribute to the environmentally sustainable growth of the fertilizer industry in the developing countries.

VI. Policy issues for workshop discussion

The experience of several countries during the 1970s and the 1980s indicates that a conducive and stable policy environment is essential for growth in fertilizer use and production. Important policy issues and options that affect fertilizer sector operations are summarized below.

A. Macroeconomic policy

Several macroeconomic policy issues affect the performance and growth of the fertilizer industry, but two of them warrant special discussion: allocation of foreign exchange and devaluation of domestic currencies.

1. Allocation of foreign exchange

Inadequate and untimely availability of foreign exchange remains the most critical constraint on the performance and growth of the fertilizer industry; it affects both fertilizer use and supply. A shortage of foreign exchange affects the fertilizer industry in several ways:

- It constrains fertilizer use by restricting the supply of imported fertilizers; this affects both the quantity and quality of fertilizers used as well as the types of products and nutrients available to farmers. For example, in many countries, foreign exchange shortages have limited the supply of phosphate and potash fertilizers and created imbalances in nutrient use.

- It affects the performance of fertilizer production units because it restricts the supply of raw materials, equipment and spare parts; in many developing countries, low capacity utilization can mainly be attributed to foreign exchange shortages.

- It affects the construction of new fertilizer plants by obliging the purchase of incompatible plant equipment, which causes inefficient plant operations.

Developing country governments must therefore allocate all the needed foreign exchange on a priority basis.

There are two options: free foreign exchange markets and fixed exchange rate regimes. When a country has a free foreign exchange market, the availability of foreign exchange is determined by the forces of demand and supply. In such a situation (which exists in, for example, Ghana), producers and importers can purchase the needed fertilizers, depending on the profitability of fertilizer operations. However, even under this scenario, macroeconomic policy plays an important role in stabilizing the exchange rate, because wide fluctuations can discourage the production and import of fertilizers and investment in them. Under a fixed exchange rate regime, the government controls the allocation of foreign exchange resources and decides on priorities. To avoid administrative delays, a special foreign exchange fund should be created for fertilizer purposes, and importers and producers should have easy access to it.

2. *Devaluation*

Rapid devaluation of domestic currency affects fertilizer use by increasing fertilizer prices and credit needs and thereby reducing the profitability of fertilizer use: moreover, it discourages fertilizer production by increasing the cost of imported raw materials, equipment and spares. Initially, devaluation encourages production by enhancing the profitability of exports, but in the long run it discourages production because of its adverse effect on domestic fertilizer use. Rapid devaluation also increases the risk of importing fertilizer.

Because devaluation is a part of the overall macroeconomic policy reform process, measures to stabilize the exchange rate should be introduced as soon as possible. In the meanwhile, some precautions should be taken to minimize its deleterious impact on fertilizer use and supply. First, foreign exchange guarantees should be introduced to ensure against the risks resulting from changes. Secondly, during the transition, fertilizer prices should be allowed to change gradually by means of temporary subsidies or other support programmes.

B. Pricing policy

Pricing policy should be formulated in such a way that it motivates both farmers and suppliers (producers and importers). To achieve that goal, many countries have instituted subsidies and pan-territorial pricing, as a result of which prices remained controlled and reasonably stable. Because pricing policy affects both fertilizer use and supply (production and imports) at different levels, several issues are pertinent.

- *Fertilizer subsidies*. There are two important issues here. One, should fertilizers be subsidized? If so, at what level? These questions should be answered taking into account the food security and environmental protection concerns and fiscal burdens at the country level. Because countries are at different stages of development, a pragmatic approach should be adopted. Although fertilizers have been subsidized at different levels, doing so at the production or import level is easier administratively and promotes a competitive marketing system. A second concern is the removal of subsidies (if it is socially desirable to do so). Again, different countries have followed different paths in this matter, but the most successful approaches have been the gradual ones. A properly sequenced scheme should be developed, and fertilizer and crop prices should be changed in such a way that fertilizer use remains profitable during the removal phase. The removal of subsidies should also be synchronized with the devaluation of domestic currency.

- *Links between domestic and international prices*. International prices remain highly volatile. Urea prices, for example, changed by 50 per cent between August 1993 and August 1994. Such a high rate of change introduces risk and uncertainty in both fertilizer use and production. Because fertilizer use is a critical component of food security strategy in many developing countries, a reasonable degree of stability in fertilizer prices might seem to imply that domestic prices should not be linked to international spot prices.

- *Free-market pricing*. In the past, many developing countries adopted pan-territorial pricing to promote equity in fertilizer use and therefore controlled fertilizer prices at the farm level. Although such policies were useful in promoting fertilizer use, they proved to be a mixed blessing because they also encouraged inefficiencies, rent-seeking groups and fiscal and administrative burdens. Another more desirable way to ensure fertilizer supplies to all parts of the country at a reasonable price is to influence fertilizer supplies by free-market pricing at the wholesale and retail levels.

- *Producer pricing.* Cost-plus pricing has been the norm in most countries, but such a system does not make the most effective use of resources and capital. A normative pricing system with built-in incentives to improve performance should be adopted, and this system should be continuously monitored to prevent its misuse.

- *Raw material pricing.* Not all countries are rich in natural gas and the other raw materials needed for fertilizer production, and natural gas is generally more expensive in energy-importing countries than in energy-exporting countries. For comparing the efficiency of the industry across countries, a uniform raw material price should be used. Pricing is of strategic importance for the fertilizer industry in achieving the socio-economic goals of food security and environmental protection.

- *Crop pricing.* Many countries have deregulated fertilizer prices without deregulating crop prices. Such asymmetric deregulation does not promote the growth of the fertilizer industry. Both crop and fertilizer prices should be deregulated to stimulate fertilizer use.

C. Marketing policy

The marketing systems in developing countries are mixed. In some countries, the public sector has a full monopoly on marketing and distribution; in others, the private sector is either fully responsible or works with public sector and cooperative enterprises. There are two important issues in this area. First, what are the roles of the public and private sectors in promoting efficient and equitable fertilizer marketing? Secondly, how should the marketing be demonopolized or privatized?

The demise of communism and the inefficiencies of SOEs have led to greater private sector involvement in fertilizer marketing, with regulatory and monitoring functions still carried out by governments. Although there is a growing consensus that the private sector should play a larger role in fertilizer marketing and that a competitive market system should replace the public sector monopoly, there is little consensus about the speed with which the transition from public sector monopoly to private sector free-market system should proceed. Some countries have followed the abrupt approach: government enterprises withdrew completely and suddenly from marketing activities before they were adequately replaced by private sector organizations. In those countries (Poland, the Russian Federation and Zambia) fertilizer use has decreased. Other countries, such as Bangladesh (where IFDC was involved in the privatization process) and China, followed a gradual approach: the private sector took control from the public sector slowly and step-by-step. Fertilizer use continued to grow in these countries even during the reform process. Because developing institutional and physical infrastructures and management skills is a time-consuming process, a gradual move towards privatization is desirable. Efforts should be focused first on retail marketing and then on wholesale marketing. Once the private sector is well established and competitive, fertilizer imports should be privatized. During this transition, the government should develop regulatory, quality control, and anti-trust measures so that public sector monopoly is not replaced by private sector monopoly.

D. Investment policy

The fertilizer industry is highly capital- and foreign-exchange-intensive. In some countries, the private sector has adequate capital and expertise to invest in production capacity; in others, such as countries in sub-Saharan Africa, the private sector does not have enough capital and expertise, nor is it able to take the necessary risks. In the former countries, the government should create an enabling environment by providing tax incentives, developing financial markets and guaranteeing the supply

of foreign exchange and price stability. In the latter, the government may have to take the lead in making the necessary investment. In such situations, issues of ownership and management warrant special discussion.

In many developing countries and in the former centrally planned economies, the distinction between ownership and management was blurred. Government ownership also resulted in government management, leading to political interference, soft budget constraints, mounting subsidies and inefficient operations. On the other hand, where fertilizer plants were managed by a technically competent management team with authority and accountability, even government-owned plants operated very well. India's IFFCO plants, Indonesia's PUSRI plants and Nigeria's NAFCON (National Fertilizer Company of Nigeria) plants are examples of well-run fertilizer plants.

In divesting existing SOEs, a plan should be followed. First, no viable plants should be divested. Then, the technical, financial and management constraints on the non-viable plants should be alleviated. Lastly, plants that cannot be made viable should be liquidated.

The growth of the public sector can be controlled by allowing additional new capacity to be constructed only in the private sector or through joint ventures. In such cases, the playing field should be levelled, that is, both sectors' plants should be subjected to the same rules, regulations and incentives. In weighing the options in this area, it should be remembered that the goal is to provide fertilizer security and, ultimately, food security.

E. Trade policy

Most developing countries have followed controlled trade regimes, i.e. fertilizer imports and exports were regulated. The regulations were designed to achieve fertilizer security and to protect the domestic sector from the volatility of international markets. When the fertilizer sectors were in their infancies in most developing countries, that is to say in the 1960s and the early 1970s, and when fertilizer prices were very high, such measures were socially desirable. However, once fertilizer markets are well developed and international markets are operating competitively, such regulations can lead to inefficiency and waste in the domestic industry and deregulation is needed. That having been said, it must be recognized that not all developing countries have developed fertilizer markets, nor should the domestic industry be exposed to international pressures without adequate preparation. Furthermore, the volatility of international prices and their impact on the health of the domestic industry and the fertilizer and food security of the country should also be kept in mind. Thus, the following issues are important in this area.

1. Demonopolization

Most developing countries created parastatals to procure and import fertilizers. Such a monopoly arrangement has a definite advantage over a large number of small importers because it benefits from economies of scale. However, when the market is fairly large, such an arrangement can create inefficiencies and lead to rent-seeking behaviour, so it should be replaced by limited competition among a small number of large importers. In a small market, on the other hand, there is little harm in keeping a monopolistic arrangement, but its activities must be constantly monitored to improve efficiency.

2. Deregulation

Several countries have restricted the import and export of fertilizers for the reasons explained above, but this action often deprives farmers of an adequate and timely supply of fertilizers. In many developing countries, a strong case can be made for increasing fertilizer imports by removing quantity controls on them. However, a balance should be kept between domestic production and imports. Import/export controls can also be used to put gentle pressure on the domestic industry to improve its efficiency.

3. Tariffs

Tariffs are generally used to discourage the consumption of imported goods and services and to protect the domestic industry from undesirable foreign competition. Trade theorists generally recommend that tariffs are better than quotas to regulate imports and protect the domestic industry. So far, few developing countries have imposed tariffs on fertilizer imports because most of them import through SOEs. However, as countries move towards liberalization (see below), tariffs could be used to keep a fair balance between the prices of domestically produced and imported fertilizers.

4. Liberalization

Many developing countries are moving towards complete liberalization of the fertilizer sector. This means no regulation on the quantity or price of imports or on organizations involved in importing fertilizers. Recently, India liberalized imports of phosphate and potash fertilizers, and Brazil, Mexico, Venezuela and other Latin American countries have done so for all fertilizers. Although this is a desirable goal in the long run, it is being carried out by different processes and at different speeds. A few points should be kept in perspective:

- The liberalization should be gradual and well planned.

- The nature, scope and speed of the process will be different for fertilizer-importing and fertilizer-exporting countries as well as for energy-importing and energy-exporting countries.

- The size of the domestic market and industry should be kept in mind. Liberalization may be more successful in small and medium-size markets than in very large markets because large markets, such as China and India, tend to become price-makers rather than price-takers in the international markets.

F. Technology and supply policy

The fertilizer industry is a process industry, and the compatibility of each process is essential. Without perfect harmony among the different processes, a plant cannot perform efficiently. In this respect there are three issues:

- There is the issue of technology selection. The developing countries should promote international competitive bidding to ensure efficient and dependable technologies, because marginal savings in equipment procurement from incompatible sources can become a source of operating problems in the long run. They should not, moreover, restrict their choice to a single technology because other technologies are eventually likely to overtake it with improvements. Macroeconomic policy should provide adequate foreign exchange support to allow selecting the best proven technology.

- In developing a supply strategy, consideration should be given to the availability of domestic raw materials. A country should not build a plant based exclusively on imported raw materials: there is little value added in the fertilizer industry, and the finished products could be bought in more cheaply. For strategic reasons, however, some plants may be built, but capacity should be kept to a minimum.

- In developing domestic resources (raw materials) for the fertilizer industry, the government should provide the necessary physical, institutional and human infrastructures. The cost of such infrastructures should not be charged to the project.

G. Environmental policy

Environmental problems in general and those related to the fertilizer industry in particular can be attributed to three factors: market failure, policy failure and the knowledge gap [18]. The market failure argument suggests that environmental problems are caused by the nonexistence of markets for environmental goods. For example, a fertilizer factory dumps a waste product, say phosphogypsum, in the river because the river is a free good and no one owns it. If the factory is required to pay the cost of the treatment, then it will find ways to prevent the damage caused by the pollutants. In economics, this is known as internalizing the externality. The policy failure argument suggests that the pursuance of wrong policies can lead to environmental damage. For example, excessive crop price support programmes can contribute to excessive use of agrochemicals such as pesticides, causing harm to both humans and the environment. The knowledge gap argument implies that a lack of knowledge about technologies, products and practices can lead to environmental damage. Eutrophication resulting from fertilizer runoffs is an example of knowledge failure. Based on these three factors and others, the following policy measures are proposed:

- Internalizing the externality means that the cost of treating pollutants is to be paid by fertilizer producers for production-related pollution and by farmers for use-related pollutants. The concept poses several problems because fertilizer use plays an important role in food production. The increased cost of environmental measures make fertilizer production more expensive, which in turn will lead to higher costs of food production and higher food prices for consumers. How much of the increased cost can be transmitted from producers to consumers depends on the price elasticity of demand and supply at each stage. Because consumers ultimately bear the burden, a case can be made for providing "social support" for implementing environmental measures in the fertilizer industry.

- Unless the policy of internalizing the externality is implemented by all countries, the countries that respond first will be losers. This requires developing a global consensus for implementing environmental measures and realistic guidelines for environmental regulations. The ideal of zero pollution may be an unrealistic and unattainable goal.

- Because fertilizers play an important role in both food security and resource preservation, sustaining growth in fertilizer use and production will be a social necessity and better social support for the industry will be required.

- Inappropriate policies leading to inadequate fertilizer use and nutrient depletion should be rescinded. Policies for environmental monitoring should be introduced, especially where fertilizer use is approaching agronomic optimum limits.

- Technologies to deal with fertilizer pollutants are available in the developed countries. To transfer these technologies to the developing countries requires foreign exchange and the training of production staff. Policy makers should provide the necessary help in technology transfer.

- Research, agricultural extension and the education of farmers should receive higher priority in preventing environmental effects associated with fertilizer use. Further research is needed in agricultural production and the environmental interactions of fertilizer use.

H. Regional cooperation

Fertilizer markets are nearly saturated in the developed countries, but these countries have the production capacity, technologies and feedstocks (raw materials) that can help satisfy fertilizer requirements in the developing countries, where fertilizer markets are growing and should continue to do so. Some developing countries too, have adequate capacity and raw materials to supply fertilizers, whereas others have the technology, expertise and capital to convert raw materials into production capacity. To promote the cooperation that needs to take place between developed and developing countries and among developing countries, the latter should remove restrictions on ownership, foreign exchange repatriation, raw material supply and prices. Joint ventures among countries should also receive greater priority. In developing joint ventures, pricing, foreign exchange availability, raw material supplies and market-sharing arrangements should receive adequate attention so that there is no room for misunderstandings such as occurred between India and Senegal.

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