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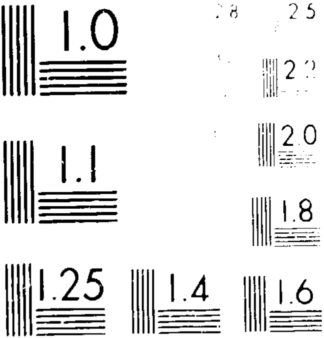
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MARKET STUDY OF MINI-FERTILIZER PLANTS FOR DEVELOPING COUNTRIES

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FOR

UNIDO

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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CONTENTS

1 - INTRODUCTION

It has been one of the anxieties of the contemporary world to question about its ability to produce and distribute enough food at reasonable prices to meet the increasing demands of growing populations and rising incomes.

The world's ability to supply food depends on: (1) availability and use of land and other natural resources; (2) technology for raising yields and increasing the efficiency of crop and livestock production; (3) weather; and (4) incentive to producers.

Although the world as a whole is clearly not running out of land, thare are serious problems about its availability and suitability for agriculture, especially among some of the developing countries. Development in the past half a century, however, has demonstrated that, as an input to agricultural production land became less important, as people learn about and can afford other means of increasing output. This tendency has become more prominent as the costs of expanding land use rise in relation to other inputs.

The major problem facing many of the developing countries is not in the limitation of land, but in that their land produces comparatively little because of low yields. Therefore, yield increasing techniques must be the primary source of growth in food production.

Fertilizer use is a key factor in yield increase, although it must be accompanied with improved varieties of seeds, improved cultivation practices and better management of water, if it is to have much impact on yields.

Taking, as an example, the performance of three major developing countries, China, India and Pakistan, during the decade of 70, the impact of fertilizer use on cereals production becomes evident. (Table 1)

Since production of food in the coming decades has been a chief concern for most of the developing countries where high growth rate of population is bound to exert pressure on the demand of food, fertilizer must play a major role in their food production.

To supply the ever increasing need of fertilizer in the developing countries, there are only two means available to those who have still not engaged in the process of production of fertilizers. Either they start structuring the process of fertilizer supply by internal production, or they must continue on their dependence of importation. Experience of the past two decades has shown that fertilizer has become an issue too vital to the security and progress of most countries to depend heavily on volatile fertilizer markets of the world. In the long run developing countries must also reach their own decision whether to use their available resources to obtain food through internal production, or to make better use of their resources in other ways than food production and resort themselves to import food, thus dispensing with the use of fertilizer altogether. Under prevalent conditions, some OPEC countries seem to be opting for this type of economic development. By a large mejority, however, developing countries must opt for higher productivity through fertilizer use. It is also to their interest that they search for a more economical, reliable and long-ranged means of fertilizer supply by internal production.

TABLE 1

INFLUENCE OF FERTILIZER USE ON CEREALS PRODUCTION

COUNTRY	1970	1980	DIFFERENCE
CHINA			
Cultivated Area (1000 ha)	88,198	102,624	+ 16 %
Yield (kg/ha)	2,379	2,760	+ 16 %
Production (1000 T cereals)	209,839	283,277	+ 35 %
Fertilizer use (kg NPK/ha)*	42.4	128.9	+ 204 %
INDIA			
Cultivated area	100,308	104,509	+ 4 %
Yield	1,108	1,386	+ 25 %
Production	111,147	144,879	+ 30 %
Fertilizer use	11.4	27.6	+ 142 %
PAKISTAN			
Cultivated area	9,673	10,897	+ 13 %
Yield	1,206	1,587	+ 32 %
Production	11,668	17,296	+ 48 %
Fertilizer use	16.8	51.9	+ 209 %
USA			
Cultivated area	77,369	91,291	+ 18 %
Yield	3,159	3,404	+ 13 %
Production	244,393	310,765	+ 27 %
Fertilizer use	80.0	110.6	+ 38 %

* kg NPK per hectare of arable land and permanent crop

The fertilizer industry of the world has developed, during the past half a century, into a highly diversified but interwoven complex. On the whole, it can be broken down into two categories of industrial activities: the fertilizer raw materials and intermediates manufacturers, and the fertilizer product processing and marketing organizations. A new-comer is always initiated into the industry through the latter, and many other established industries, such as the chemical industry and the petroleum industry, diversified themselves into the fertilizer industry through the former. Generally, the latter would naturally grow into the former as their volume of market expands into a higher level.

Whichever the stage of advancement the industry finds itself in, its manufacturing plants must be dimensioned in accordance to the demand of its market. The modern fertilizer complexes of the developed countries did not reach their current dimensions until volumes of their markets reached corresponding levels. Even then, throughout the past decades, there had been occasions in which a great number of those plants have had to be kept idle whenever there were upsets in the market.

To achieve some measure of sufficiency in fertilizer supply, most developing countries, except for a few major ones such as China, India, Brazil, and Pakistan which already possess a substantial foundation in fertilizer production, will have to go through some fundamental development in the fertilizer industry in the coming decades. Like all those countries, developed or developing, which had been through this process, fertilizer industry designed for internal consumption always started with comparatively small scale manufacturing plants, in the range of what is now called mini-fertilizer plants. The employment of mini-fertilizer plants as an instrument of fertilizer supply in the developing countries in the coming decades, therefore, must be treated as a natural phenomenon in the process of economic development.

Based on this premise, UNIDO has decided to develop the project of Mini-Fertilizer Plants for Developing Countries, with the purpose of identifying precisely what these mini-fertilizer plants are, and of finding out how they can be built economically. In order to be able to build mini-fertilizer plants economically, two conditions are important. First, there should be a ready market for these plants in sufficient numbers to warrant the effort of some measure of standardization, so as to eliminate some repetitive expenditures such as engineering costs. Second, only in sufficient numbers of each type of plants can high costs of supplying machinery and equipment on a "one-of-a-kind" basis can be avoided.

As a part of the UNIDO Mini-Fertilizer Plants for Developing Countries Project, this study is elaborated in an effort to evaluate the magnitude of the potential market for mini-fertilizer plants in the developing countries in the coming two decades.

In the evaluation of the market for mini-fertilizer plants, projections of fertilizer consumption in each developing country in the decades of 80 and 90 are made, following the trend of the 70's. The estimated requirement of fertilizers over and above their existing production capacity can be obtained either by building production plants, or by importation from other producer countries, naturally with the expenditure of foreign exchange.

Under normal conditions, no developing country can sustain a long ranged policy of dependence on imported fertilizer. Therefore, there is a high degree of possibility that at least a part of the estimated number of mini-fertilizer plants required by developing countries in the coming two decades will come to be built. Eventually, as the fertilizer market of a country reaches high levels, the factor of economy of scale of new fertilizer plants will come into play. The dimensions of the mini-fertilizer plants, as they are conceived presently, may then become uneconomical. Even then, many factors such as logistics may come into play so that mini-fertilizer plants will still have their place under those conditions.

Identification of markets for these mini-fertilizer plants does not necessarily mean that they will be built. Many other conditions than purely economic ones will have to be involved before concrete measures can proceed. Nevertheless, the magnitude of the task is clearly identified in this study. It is believed that the consumation, even if partially, of some of these measures will go a long way toward improving productivity in food production of some developing countries in particular and help accelerate economic development of those countries in general.

In the elaboration of this study, data base are obtained from the following organizations:

1. FAO,Food and Agriculture Organization of the United Nations, Rome.

2. ERS, Economic Recearch Service, United States Department of Agriculture, Washington DC.

3. IFDC, International Fertilizer Development Center, Muscle Shoals, USA.

4. TVA, Tennessee Valley Authority National Fertilizer Development Center, Muscle Shoals, USA.

5. IFA, International Fertilizer Industry Association Limited, Paris.

6. Bureau of Mines, United States Department of the Interior, Washington DC.

Some relevant information are also obtained from various publications among which special mention should be made to "The Future Ammonia Business "prepared by Chem Systems International Ltd. in 1980.

2. EVOLUTION OF FERTILIZER CONSUMPTION AND SUPPLY IN DEVELOPING COUNTRIES

2.1. Pattern of Fertilizer Consumption

2.1.1. WORLD CONSUMPTION OF FERTILIZER NUTRIENTS

The historical record of the consumption of fertilizer nutrients from 1950 to 1980, and projections to 2000 made therefrom, is shown in Table 1 and Figura 1.

TABLE 1

WORLD FERTILIZER CONSUMPTION ($IX10^6$ TONS NUTRIENTS)

	DEVELOPING COUNTRIES				DEVELOPED COUNTRIES				WORLD			
	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK
1950	0.56	0.36	0.09	1.01	3.19	5.41	4.04	12.60	3.75	5.77	4.13	13.65
1960	1.95	0.94	0.42	3.31	7.30	8.90	7.83	24.50	9.95	9.84	8.25	28.04
1970	7.70	3.25	1.47	12.40	21.00	15.60	14.00	50.50	28.70	23.30	15.47	67.47
1980	22.55	8.19	3.48	34.20	34.65	22.89	19.97	77.50	57.20	31.08	23.45	111.73

On examination of these data, it is evident that. percentage-wise, the gap is diminishing between consumption of fertilizer nutrientes of the developed and the developing countries. In terms of volumes, however, the difference is substantial. For example, the difference of consumption in 1980 between developed and developing countries was 43.3×10^6 tons nutrients, or more than

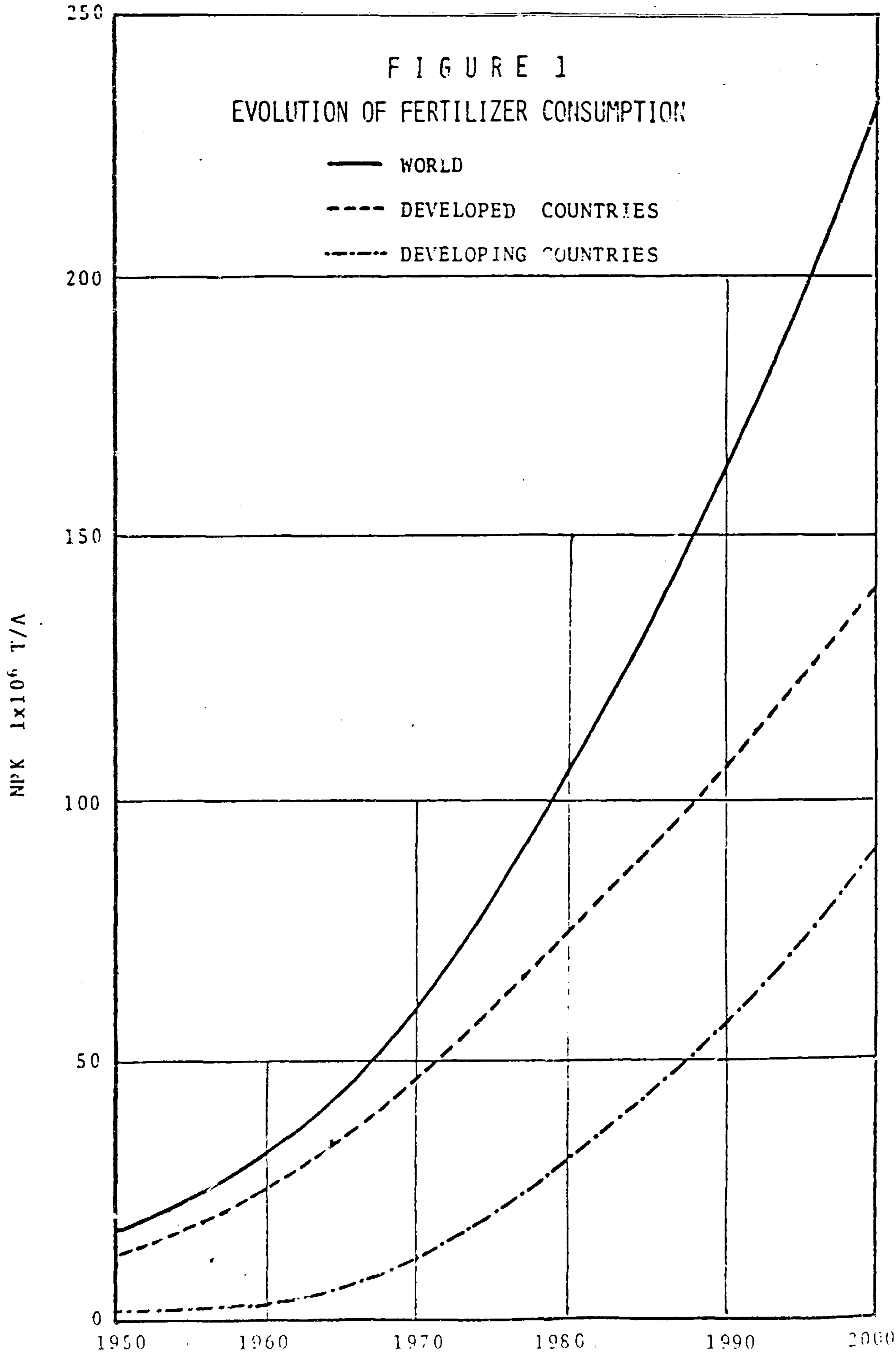
FIGURE 1
EVOLUTION OF FERTILIZER CONSUMPTION
WORLD
DEVELOPED COUNTRIES
DEVELOPING COUNTRIES
NPK 1x10⁶ T/A
250
200
150
100
50
0
1950
1960
1970
1980
1990
2000

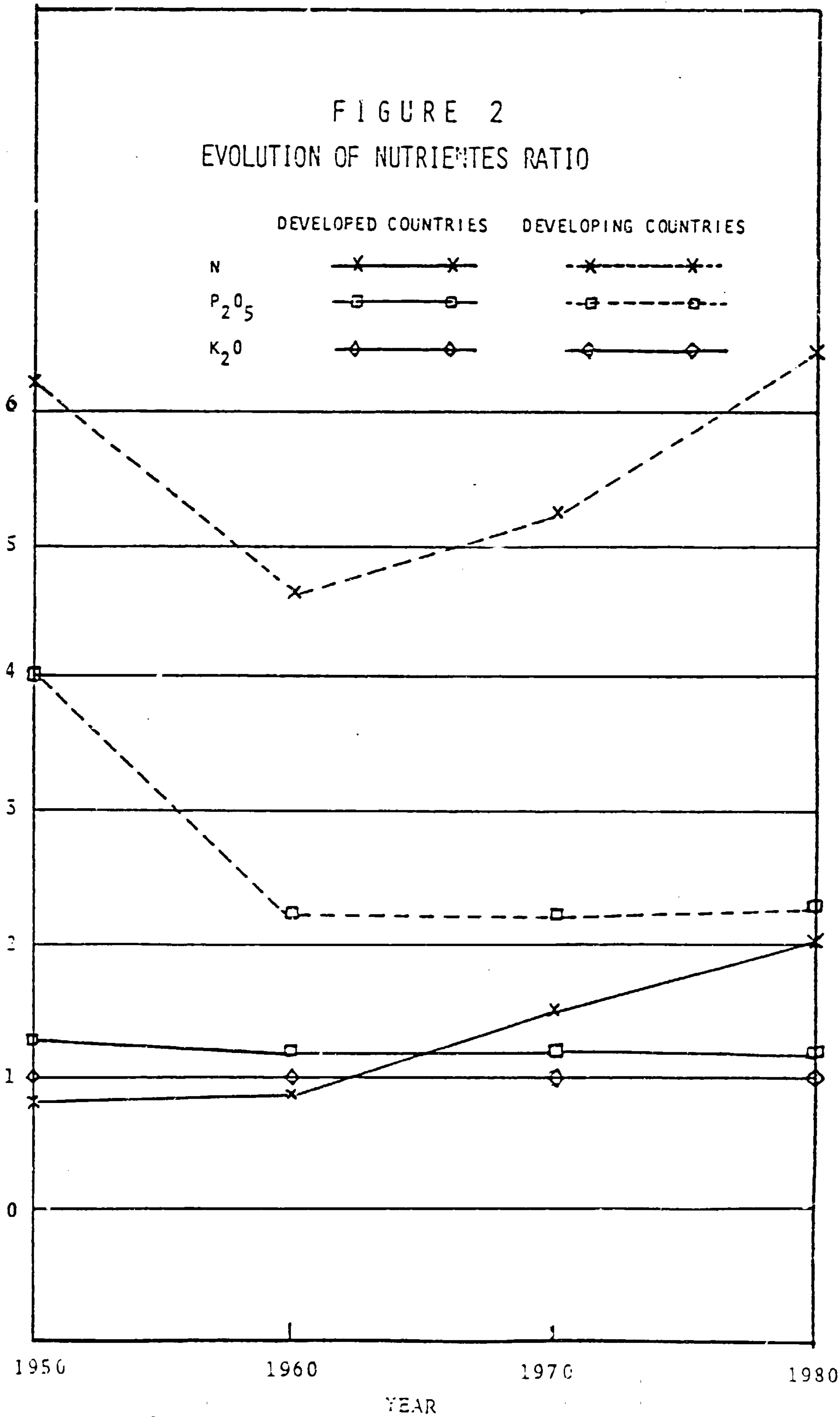
FIGURE 2
EVOLUTION OF NUTRIENTES RATIO
DEVELOPED COUNTRIES
DEVELOPING COUNTRIES
N
P_2O_5
K_2O
6
5
4
3
2
1
0
1950
1960
1970
1980
YEAR

100×10^6 tons of fertilizer products. On the other hand, looking into the future, the developing countries increase in fertilizer consumption from 1980 to 2000 may reach 58 million tons in nutrients, or almost 150 million tons of fertilizer products. This is an indication of the magnitude of the task to supply the developing countries with this substantial additional volume of fertilizers per year at the end of this century. (See 3.1.)

2.1.2. EVOLUTION OF NUTRIENT RATIO

The nutrient ratio ($N : P_2O_5 : K_2O$) in the fertilizers consumed in the developed and developing countries (Figure 2) show a preponderance of nitrogenous fertilizer consumption in both group of countries, with the developing countries demonstrating an exaggeratedly high index of 6 : 2 : 1. This should not to be taken as an agronomically founded practice. This distorted ratio is resulted because very little potash is being used, and in many case, not enough phosphorous is being applied. Nitrogen is the nutrient which will bring in an immediate response in productivity. Therefore, it is always the first element to be used in introducing fertilizers to a farmer. Nevertheless, it clearly points to the fact that nitrogen will continue to be the predominant fertilizer nutrient in consumption, and therefore the main activity of the fertilizer industry.

2.2. EVOLUTION OF SUPPLY OF FERTILIZERS

2.2.1. EVOLUTION OF PRODUCT MIX

During the past 30 years, product-mixes in the major fertilizer consuming countries have undergone significant changes. In general, the trend has manifested itself toward several directions. First, there is a general upgrading in nutrient content of the intermediates expecially the binaries and of compound fertilizer products. Second, there has been a movement toward liquids or suspensions which, on a large scale, bring down transportation and application costs, besides obtaining other related benefits.

The actual product-mix used in a country or a region depends not so much on the demand pattern as on the supply structure. For a country which possesses the capability to supply a major portion of its consumption by internal production, it can exert a certain degree of control over its product-mix. For those countries which still depend, to some degree, on the importation of fertilizer materials, there is little control over their product-mix because international trade in fertilizer material tends to be confined to several standard items.

Table 2 demonstrates several examples of fertilizer product-mix which was prevalent in 1980. In general, a product-mix is the result of evolution over a long period of time. There is always a historical background which influences its development. Therefore, change in a major component of an existing product-mix, either in its consumption or in its production, usually comes slowly. For the same reason, once a product is introduced into a product-mix, it tendo to stay, even though it may not be so adequate economically or agronomically.

This phenomenon makes it difficul . developing country to choose its alternatives in starting process of internal production of fertilizers. For a market which has been using imported triple superphosphate in its product-mix, for example, it may seem retrogressive to enter into the production of single superphosphate. On the other hand, the production of triple superphosphate requires the use of phosphoric acid, the manufacturing of which may not be feasible for some one who has not been through the stage manufacturing single superphosphate. Furthermore, single superphosphate is intrinsically a better fertilizer because of its sulfur content and higher calcium level. Commercially, however, these additional values are not recognized and therefore not paid for. On the contrary, single superphosphate is sometimes penalized commercially for its low P_2O_5 content.

TABLE 2

COMERCIAL PRODUCT-MIX OF THE WORLD

TYPE OF FERTILIZER		GRADE
NITROGEN FERTILIZERS		
Conventional:	Ammonia, anhydrous	82-0-0
	Ammonium Sulfate	20-0-0
	Ammonium Nitrate	33-0-0
	Urea	45-0-0
Non-Co nventional:	Agua ammonia	15/20-0-0
	Ammonium bicarbonate	17-0-0
	Ammonium chloride	25-0-0
PHOSPHATE FERTILIZERS		
Conventional:	Single superphosphate (SSP)	0-18/20-0
	Enriched superphosphate	0-25/30-0
	Triple superphosphate (TSP)	0-46-0
Binary intermeidates:	Diammonium phosphate (DAP)	18-46-0
	Monoammonium phosphate (MAP)	11-54-0
	Nitrophosphates	20-20-0 etc.
Non-conventional:	Ammoniated SSP	4-16-0
	Ammoniated TSP	6-38-0
	Basic slag	0-10/20-0
	Fused calcium magnesium phosphate*	0-17-0
	Ground reactive natural phosphates**	0-30-0
	Partial acidulation phosphate***	0-30/15/10-0
POTASSIUM FERTILIZERS		
Conventional:	Nutriate of potash	0-0-60

Comercial names: * Thermophosphate **Hyperphosphate
***Kotka phosphate

TABLE 2

TYPICAL FERTILIZER PRODUCT-MIX OF SOME DEVELOPED AND DEVELOPING COUNTRIES (1980)

COUNTRY	BANGLADESH	BRAZIL	CHINA	W. GERMANY	INDIA	MALAYSIA	PAKISTAN	U S A
1. NITROGEN FERTILIZERS (10^3 TN)	266.7	783.4	10.551.5	1.550.0	3.529.7	139.4	875.3	10,692.1
1.1. Straight Nitrogen								
Nitrates, Calcium and ammonium		14 %		70 %	4 %	7 %	8 %	9 %
Ammonium sulfate		24 %		4 %	3 %	5 %	2 %	2 %
Urea	97 %	28 %	40 %		79 %	52 %	70 %	8 %
Ammonium Bicarbonate			40 %					
Anhydrons ammonia								39 %
N solutions			15 %					17 %
Other straight N			5 %	1 %		4 %		1 %
1.1. Compound Nitrogen								
NP Compouds	3 %	24 %		5 %	8 %	2 %	19 %	6 %
NPK Compounds		5 %		20 %	6 %	30 %	1 %	
Other compounds		5 %						18 %
TOTAL N	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
2. PHOSPHATE FERTILIZERS (10^3 TP_2O_5)	119.9	1,676.2	1.952.6	837.5	1.090.9	118.8	243.6	4,925.8
2.1. Straight Phosphate								
Basic Slag				16 %				0,1 %
Single superphosphate		16 %	80 %		16 %		8 %	0.4 %
Triple Superphosphate	99 %	39 %		4 %	1 %	2 %		9.7 %
Ground Rock Phosphate		7 %			2 %	57 %		
Other Straight Phosphate			20 %	4 %				0.3 %
2.2 Compound Phosphate								
NP Compounds	1 %	31 %		13 %	48 %	6 %	91 %	33.9 %
PK Compounds				26 %				
NPK Compounds		7 %		37 %	33 %	35 %	1 %	55.0 %
TOTAL P_2O_5	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
3. POTASSIUM FERTILIZERS (10^3 T K_2O)	22.3	1.085.0	295.8	1,144.1	617.6	194.0	10.1	5.659.5
3.1. Straight Potash								
Potassium Chloride	93 %	96 %	100 %	30 %	99 %	71 %	91 %	50.0 %
Others		2 %		4 %	1 %	5 %		2.0 %
3.2. Compound Potash								
PK, NK, NPK Compounds	7 %	2 %		66 %		24 %	9 %	48.0 %
TOTAL K_2O	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

By the same token, urea has become by far the predominant nitrogen fertilizer of the developing countries. The production of urea, however, requires higher investment as well as higher production cost. The use of ammonium bicarbonate may not appeal to some one who has been used to urea. The introduction of ammonium bicarbonate as a new ingredient into an existing product-mix has never been tried before. It is conceivable that there will be resistence on the part of the farmer, unless there is substantial reduction of cost to him.

2.2.2. EVOLUTION OF THE NITROGEN FERTILIZER INDUSTRY

All nitrogen fertilizers originate from synthetic anhydrous ammonia. Since fertilizer production accounts for the major part of ammonia produced, the nitrogen fertilizer industry and the synthetic ammonia industry are almost synonymous. Table 3 shows the end uses of all ammonia produced in major regions of the world.

TABLE 3

CONSUMPTION OF AMMONIA BY END USE (1977)
(10^3 T N)

REGION	FERTILIZER PRODUCTION	TECHNICAL USES	TOTAL
North America	10,910	3,130	14,040
Latin America	1,320	150	1,470
West Europe	9,435	2,380	11,815
East Europe	15,293	1,537	16,830
Japan	1,399	1,116	2,545
China	5,227	50	5,277
Rest of Pacific	1,844	-	1,844
Indian Sub Continent	2,500	-	2,500
Middle East	950	-	950
Africa	700	160	860

The synthetic ammonia industry, throughout the decades, has evolved from small scale units into 1000 T NH_3/D unit following one determining parameters: market of ammonia. Even though most of the new ammonia plants implanted during the past decade have been large sized units, there is a state of co-existence of the small and medium sized plants with the large ones. Table 4 shows existing capacities of ammonia units in the major regions of the world.

TABLE 4

EXISTING AMMONIA PLANTS

(1977)

REGION	250-500 10^3 TN/A	100-250 10^3 TN/A	10-100 10^3 TN/A	TOTAL NUMBER	TOTAL CAPACITY 10^3 TN/A
North America	25	31	45	101	15,950
Latin America	5	4	16	25	2,733
West Europe	24	23	36	83	14,516
East Europe	24	67	47	138	21,578
Japan	6	7	9	22	3,671
China (1980)	13	8	1,400	1,420	12,000
Rest of Pacific	0	8	20	28	1,840
Indian Sub Continent	2	16	13	31	4,138
Middle East	2	6	6	14	2,012
Africa	1	4	5	10	778
TOTAL	102	174	1597	1872	79,226

Analyzing the existing ammonia capacity of the world, an overwhelming number falls under the "mini-fertilizer plant" category. Most of these plants had been built in the decades of 50 and 60, before the advent of centrifugal compressores. The group with the highest capacity, East Europe, includes 13,000 x 10^3 TN/A capacity of USSR. All of them are planned economy countries.

On an individual basis, USA leads in with 17.7 % of world capacity, USSR with 16.4 %, China with 15 %. These three countries altogether account for 50 % of total world ammonia capacity.

Although anhydrous liquid ammonia can be used directly as nitrogen fertilizer, as 4 million tons per year of it is being so used in the U.S.A., most of it is transformed into fertilizers through downstream processing units. Since the emergence of urea as a major nitrogen fertilizer for the developing countries, many newly built ammonia plants are provided with a downstream urea plant. For those whose main nitrogen fertilizer contains nitrates, Europe for example, a part of the ammonia produced is converted into nitric acid. For those who produce ammonium phosphates, especially DAP, ammonia is used directly in the neutralization-granulation systems.

China has been the only country to use ammonia in a non-conventional form as nitrogen fertilizer. Since early 60's, a major portion of its ammonia production is converted into ammonium bicarbonate. Substantial quantities of agua ammonia is also produced and used in direct application.

2.2.3. EVOLUTION OF THE PHOSPHATE FERTILIZER INDUSTRY

Prior to the decade of 50, single superphosphate had been the principal phosphate fertilizer of the world. With the advent of concentrated phosphate fertilizers such as triple superphosphate and diammonium phosphate, single superphosphate has become a secondary phosphate fertilizer in most of the developed countries. Nevertheless, substantial quantities are still being produced in many countries where single superphosphate remains to be their prime phosphate fertilizer. Table 5 shows the single superphosphate production of several countries and its percentage weight in their total phosphate production.

TABLE 5

PRINCIPAL SINGLE SUPERPHOSPHATE PRODUCERS OF THE WORLD (1980)

COUNTRY	SINGLE SUPERPHOSPHATE PRODUCTION		% TOTAL P_2O_5 PRODUCTION
	T/A-P_2O_5	T/A-SSP	
China	1,280,000	6,400,000	68 %
Australia	919,000	4,600,000	100 %
Poland	555,000	2,780,000	60 %
New Zealand	410,000	2,050,000	100 %
U.S.A.	348,000	1,740,000	4 %
Brazil	240,000	1,200,000	19 %
India	168,000	840,000	22 %
Hungary	156,000	780,000	69 %
Italy	142,000	710,000	23 %
Spain	102,000	510,000	21 %

Most of the producers of single superphosphate possess captive source of sulfuric acid and bought phosphate rock. Production units capacity vary from 10 to 50 t/hr or 50,000 to 250,000 T/A.

The production of concentrated phosphates reguires phosphoric acid. Phosphoric acid, therefore, became the principal raw material of phosphate fertilizer peoduction. Wet process phosphoric acid units have developed from small operations of 10-50 T/D P_2O_5 in the decade of 40, to trains of 1000 T/D P_2O_5 capacity.

Large scale phosphoric acid plants tend to be located near the phosphate rock mines. There are cases where phosphoric acid plants were built near the source of sulfuric acid. The majority of phosphoric acid, plants, however, are integrated into downstream fertilizer complexes. There are instances where phosphoric acid plants are built exclusively for international trade, hence in deep water ports. Table 6 shows existing phosphoris acid plant capacity in major regions of the world.

TABLE 6

EXISTING PHOSPHORIC ACID PRODUCTION CAPACITY (1982)

(1000 TONS P_2O_5 PER ANNUM)

REGION	UNITS > 100	UNITS < 100	TOTAL CAPACITY
North America	43	18	11,220
Latin America	6	10	1,500
West Europe	14	49	4,360
East Europe	33	17	6,600
Oceania	0	7	290
North West Africa	12	6	2,640
Rest of Africa	4	10	1,070
Near East	6	9	1,600
South Asia	2	14	790
South East Asia	3	24	1,300
TOTAL	123	164	31,370

In terms of volume, the most important concentrated phosphate fertilizer produced in the world is ammonium phosphate, mostly diammonium phosphate. High concentration both in N and P_2O_5 contents, ease in handling and transport, and absence of acidity and hydroscopicity have made it into the second most important fertilizer product in the international trade; urea being the first. In 1980, 8.7 million tons of urea and 5.6 million tons of ammonium phosphate had been exported from various producer countries of the world. Table 7 shows the quantity of ammonium phosphate production in various countries.

TABLE 7

PRODUCTION OF AMMONIUM PHOSPHATE
(YEAR 1980 IN TONS P_2O_5)

COUNTRY	PRODUCTION	EXPORTS
U.S.A.	5,007,000	2,095,000
Poland	313,000	-
Korea, Rep.	306,000	273,000
Brazil	284,000	-
India	154,000	-
Morocco	90,000	38,000
Netherlando	84,000	34,000
Belgium	48,000	-
Iran	46,000	-
Mexico	32,000	2,300
Portugal	15,000	-

2.2.4. EVOLUTION OF POTASH FERTILIZER INDUSTRY

There is practically only one commercial potash fertilizer in the world, muriate of potash, and six countries supply 93 % of world consumption. For this reason, muriate of potash is the highest volume fertilizer in the international trade. Of a total of 23.8 million tons per year of potash (K_2O) produced in the world, 15.66 millions K_2O as muriate of potash enter into the export market. This is 26.1 million tons of product.

Unlike nitrogen and phosphate fertilizers, muriate of potash cannot be produced from other feedstock than sylvinite, carnallite and related minerals. This is the reason why production is limited to only six countries. Table 8 shows the principal producers of the world.

TABLE 8

PRODUCTION OF MURIATE OF POTASH
(1980)

COUNTRY	K_2O T/A	KCL T/A
Canada	7,063,000	11,770,000
USSR	6,635,000	11,060,000
Germany East	3,395,000	5,660,000
Germany, West	2,137,000	3,562,000
France	1,915,000	3,192,000
USA	1,700,000	2,830,000

2.2.5. EVOLUTION OF FERTILIZER PROCESSING INDUSTRY

The industrial pattern around which the fertilizer raw materials and intermediates are processed into fertilizer products in a country depends on the state of its agricultural development and its system of marketing of fertilizers.

In most planned economy countries where fertilizer production and distribution are not conducted under the same organization, fertilizer industry, as such, isresponsible only for the production of intermediates, and a limited number of formulated compound fertilizers. Generally, on the farm level, the end user of fertilizers in these countries have little influence over the fertilizer it receives. The industry, on the other hand, would not be responsible for the distribution and marketing of its products, which can be complex and labour intensive, if not so capital intensive as manufacturing. The fertilizer industry, therefore, confines itself to the production of a relatively simple product-mix. The processing of intermediates into final fertilizer products is likely to be a simple operation in these countries.

In a market economy country, the fertilizer industry usually covers a complete range of activities, from the production of raw materials to the manufacturing of intermediates; from the processing of intermediates into final fertilizer products; and from the distribution to the application of fertilizers on the farms. Depending on the size and logistics of the market, a fertilizer industry can participate in one or more or all of the activities.

The development of the fertilizer processing sector of the industry has been centered around two operations, formulation of compound fertilizers and physical conditioning of the final products. This operation can be made in one unit or in several separated units. In the case of availability of all the intermediate compounds, such as superphosphates, ammonium phosphates and potash, already in their final form, powdered or granulated, this operation is simplified into formulation by bulk blending and bagging in blending machine. Since a great majority of modern fertilizers is sold in the granulated form, a granulation unit is essential in most fertilizer plants. With the presence of a granulation unit in a fertilizer plant, it becomes possible to producce either granulated intermediate compounds or granulated compound fertilizers of various kinds of formulation. The general trend in the industry is to use the granulation unit not only as an instrument for formulation and granulation, but also to produce in the granulation unit all the nutrients in the final form from basic raw materials, namely ammonia, sulfuric acid and phosphoric acid, and muriate of potash. In other words, whereas a granulation unit originally started as a physical operation of formulation and granulation of solid intermediate fertilizer compounds, it has since become a combined chemical and physical processing unit.

Together with either a bulk blending or a granulation unit, there are some necessary auxiliary installations which require substantial investments. Bulk storage facility is one of the more important of such installations. Since fertilizer is only applied during a short period of the year, and since no production and processing unit can be dimensioned to attend only to fertilizer market demand of that short period, ample storage space must be available not only for the intermeidates or raw materials to be processed, but also for final products. In the case of the fertilizer industry in the market economy countries, the storage capacity of the final products is usually extended to the farm gate.

3. POTENTIAL DEMAND AND SUPPLY OF FERTILIZERS IN DEVELOPING COUNTRIES

3.1. PROJECTION OF FERTILIZER DEMAND IN DEVELOPING COUNTRIES

The potential demand of fertilizer in a country depends on many factors. The most important one is its historical trend of fertilizer use. The adoption of fertilizer use in agriculture, the availability of fertilizers to the farmer and the capability of the farmer to use fertilizer are evolutionary processes which tend to be gradual. These processes, however, can be hastened or retarded by the influence of many economical and political factors. Therefore, projection of potential fertilizers demand can be a complex exercise with haphazard results.

Since the purpose of this study is confined to the evaluation of the magnitude of market for fertilizer production plants which could be required, to mect the fertilizers demand of the developing countries in the coming two decades, it is thcught sufficient to estimate the future demand by following the trend of fertilizer consumption of the past decade with a normal growth rate for the coming decades.

3.1.1. DEVELOPING COUNTRIES STUDIED

Countries projected in this study are selected by economic regions with no other criterion than that their real and potential volume of fertilizer consumption could reach such a level as to warrant the effort of some form of internal production.

AFRICA

North West Africa: Algeria, Morocco, Tunisia

West Africa : Ghana, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone

Central Africa : Angola, Cameroon

East Africa : Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozanbique, Zimbabwe, Tanzania, Zambia

LATIN AMERICA

Central America : Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama.

Caribbean : Cuba, Dominican Republic

South America : Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Paraguay, Peru, Uruguay, Venezuela

NEAR EAST

Near East Africa : Egypt, Lybia, Sudan

Near East Asia : Cyprus, Iran, Iraq, Jordan, Lebanon, Saudi Arabia, Syria, Turkey

FAR EAST

South Asia : Bangladesh, India, Pakistan, Sri Lanka

East and south East Asia	:	Burma, China, Indonesia, Korea DPR, Korea Republic, Malaysia, Philippines, Thailand

3.1.2. PROJECTION OF CONSUMPTION OF FERTILIZERS IN DEVELOPING COUNTRIES

Table 9 shows the potential fertilizer consumption in the developing countries analyzed in this study. The projections are based on the consumption figures of 1971 to 1980 published in the "FAO Ferfilizer Year Book", of 1980. The annual growth rates emploryed in this evaluation follow the general trend of the developing countries predicted by FAO'S "AGRICULTURE: TOWARD 2000". However, some adjustment in the rates is made in projecting each country's future consumption, instead of using a uniform rate. For example, for countries which had been through a period of sustained high growth, evidently the future rate could not be the same as those which have recently entered into fertilizer usage.

For the purpose of estimating potential. fertilizer production facilities requirement in the coming decades, it would be useful to analyze individually the magnitude of consumption of each country. This magnitude of consumption would have a direct bearing on the dimension of ite production plants. Table 10 is an analysis of the number of countries in several orders of magnitude.

TABLE 9 - A

PROJECTION OF FERTILIZER CONSUMPTION IN DEVELOPING COUNTRIES

(1000 T/A OF NUTRIENTS)

COUNTRY	1980				1990				2000			
	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK
AFRICA												
N.W. Africa												
Algeria	66	85.5	27.5	176	132	165	55	352	266	333	111	7[illegible]2
Morocco	102	79.5	44.8	226	204	159	89	452	410	320	180	910
Tunisia	28.9	30.8	3.9	63.7	57.8	61.7	8	127	116	123	16	295
W. Africa												
Ghana	8.0	5.7	4.6	18.3	16.0	11.5	9.2	36.6	32	23	18	73
Ivory Coast	12.8	6.1	18.4	37.4	25.7	12.3	34.8	74.8	51.4	24.6	73.6	14.6
Liberia	2.3	1.2	1.2	4.7	4.7	2.3	2.3	9.4	9.4	4.7	4.7	19.0
Nigeria	61.0	35.0	17.4	113	122	70	35	227	244	139	67	453
Senegal	7.9	13.5	7.9	29.3	15.8	27.0	15.8	58.6	31.5	54.0	31.5	117
Sierra Leone	1.4	1.0	0.3	2.7	3.1	2.3	0.8	6.2	6.0	4.6	1.5	10.1
C. Africa												
Angola	10.1	2.1	2.1	14.4	20.1	4.3	4.3	28.7	40.2	8.6	8.6	57.4
Cameroon	12.0	5.7	11.3	29.0	24.0	11.3	22.7	58.1	48.0	22.9	45.4	116.0
E. Africa												
Ethiopia	28.4	53.6	0	82.0	56.7	107.2	0	163.9	113	214	0	327
Kenya	20.4	18.0	7.8	46.2	40.8	36.0	15.9	92.7	81.6	72.0	31.8	185.0
Madagascar	3.7	0.9	3.7	8.4	7.5	1.9	7.5	16.8	1[illegible].0	3.7	15.0	33.7
Malawi	15.0	4.5	3.5	23.0	30.0	9.0	7.0	46.0	60.0	18.0	14.0	92.0
Mauritius	9.6	2.4	14.7	26.7	19.2	4.0	29.5	53.5	30.0	9.6	47.0	106.6
Mozanbique	11.4	3.1	4.2	28.5	22.8	6.3	8.4	57.0	45.6	12.4	16.8	114.0
Zimbabwe	59.2	38.2	28.5	126	88.8	57.4	42.8	189.0	133	86	64	283
Tanzania	23.5	5.4	1.8	30.7	47.0	10.8	3.6	61.4	94.0	21.6	7.2	123
Zambia	43.5	15.3	4.1	62.9	87.0	30.6	8.2	127	174	61	16	251
TOTAL AFRICA	527.1	407.5	207.7	1,149	1,025	790.6	401.8	2,238	2,000	1,556	769	4,386
LATIN AMERICA												
C. America												
Costa Rica	41.6	13.5	28.6	83.7	66.6	21.6	45.8	134.0	[illegible]06.6	3[illegible].6	73.3	212.5
El Salvador	52.5	18.8	6.3	77.6	84.0	30.0	10.0	124.0	134.4	48.0	16.0	198.0
Guatemala	58.8	28.4	20.6	107.9	94.2	45.4	33.0	172.6	151.0	72.6	52.8	276.4
Honduras	10.4	3.2	6.1	19.7	16.6	5.2	9.8	31.6	26.6	8.3	15.7	50.6
Mexico	853.6	265.9	63.0	1,183	1,366	425	101	1,992	2,186	680	162	3,028
Nicaragua	26.2	15.9	12.8	54.9	42.0	25.4	20.5	87.9	67.2	40.7	23.8	131.7
Panama	12.2	6.8	11.4	3[illegible].4	19.5	10.9	18.3	48.7	31.0	17.0	29.0	77.0
Caribbean												
Cuba	300	72	160	532	480	115	356	850	768	183	410	1.361
Dominican Rep.	35.7	18.2	20.6	74.5	57	29	33	119	91	46	53	190

TABLE 9-B

PROJECTION OF FERTILIZER CONSUMPTION IN DEVELOPING COUNTRIES

(1000 T/A OF NUTRIENTS)

COUNTRY	1980				1990				2000			
	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK
S. America												
Argentina	59.5	59.5	10.8	129.9	95.3	95.3	17.3	207.9	152	152	28	332
Bolivia	1.9	2.5	0.6	5.0	3.7	4.9	1.2	9.8	7.4	10.0	2.4	19.8
Brazil	809	1,720	1,112	3,641	1,300	2,750	1,780	5,830	2,080	4,400	2,850	9,330
Chile	55.1	72.0	13.6	140.7	88.0	115.0	21.7	224.7	140.0	184.0	34.7	358.7
Columbia	175.0	84.6	81.5	341.1	280.0	135.4	130.4	545.8	448.0	217.0	209.0	864.0
Ecuador	46.5	32.4	21.6	110.5	74.4	52.0	34.6	161.0	120.0	83.0	55.4	258.4
Paraguay	1.2	0.9	1.5	3.6	2.5	1.8	3.1	7.3	4.9	3.7	6.1	14.7
Peru	88.6	15.9	8.9	113.4	[illegible]	25.5	14.2	181.4	226.7	40.8	22.7	290.2
Uruguay	24.5	73.4	4.9	102.8	[illegible]	95.5	6.4	133.8	41.6	124.0	8.3	173.9
Venezuela	94.7	69.3	52.3	216.2	[illegible]	[illegible]	105.0	432.0	300.0	220.0	168.0	688.0
TOTAL LATIN AMERICA	2,747	2,573	1,637	6,927	[illegible]	4,271	2,641	11,394	7,082	6,560	4,220	17,856
NEAR EAST												
Near East Africa												
Egypt	514.2	101.1	8.4	624.7	823.0	162.0	13.5	998.5	1,316	260	21.6	1,599
Lybia	20.6	33.1	1.1	54.8	41.0	66.0	2.3	109.3	82.0	132.0	4.6	218.6
Near East Asia												
Cyprus	13.1	12.3	2.2	27.6	21.0	19.7	3.5	44.2	33.6	31.5	5.6	70.7
Iran	246.4	158.0	-	404.4	493.0	316.0	0	809.0	789	506	0	1,295
Iraq	77.6	26.3	2.6	106.5	155.1	52.5	5.3	212.9	310	105	10	425
Jordan	4.6	4.6	1.6	10.8	9.2	9.2	3.2	21.6	18.4	18.4	6.4	43.2
Lebanon	17.5	25.2	6.4	49.1	33.0	52.4	12.8	98.2	70.0	100.8	25.6	206.4
Sandi Arabia	13.2	4.9	0	18.1	26.0	9.7	-	35.7	52.0	19.4	-	71.4
Syria	75.1	44.4	2.6	122.0	[illegible]	[illegible]	5.1	243.9	300.0	177.6	10.2	487.8
Turkey	789	690	27	150.6	[illegible]	[illegible]	44	2,410	2,021	1,745	70	3,856
TOTAL NEAR EAST	1,831	1,090	52	2,984	[illegible]	[illegible]	90	4,963	4,993	3,116	154	8,272
FAR EAST												
South Asia												
Bangladesh	254.4	118.7	25.4	398.5	[illegible]	[illegible]	50.9	797.1	1,018	475	102	1,593
India	3,541	1,042	556	5,138	[illegible]	[illegible]	989	8,221	9,066	2,666	1,422	13,154
Pakistan	837.8	243.5	8.3	1,090	[illegible]	[illegible]	13.3	1,743	2,144	623.4	21.3	2,789
Sri Lanka	89.6	37.1	35.5	162.1	[illegible]	[illegible]	57.0	259.0	229.0	94.0	91.0	414.0
East and S.E. Asia												
Burma	74.0	31.7	3.5	109.2	[illegible]	[illegible]	7.0	218.4	237	101	11	349
China	10,165	1,906	90.8	12,162	[illegible]	[illegible]	182	18,225	19,923	6,100	363	26,387
Indonesia	650.5	154.9	93.0	898.4	[illegible]	[illegible]	186	1,797	2,600	620	370	3,590
Korea DPR	554.0	130.9	84.3	769.2	[illegible]	[illegible]	119	1,077	1,086	257	165	1,508
Korea Rep.	450.6	221.5	195.0	867.1	[illegible]	[illegible]	312.0	1,387	1,154	567	499	2,220
Malaysia	145.0	104.0	218.0	467.0	[illegible]	[illegible]	436.0	934.0	464.0	333.0	698.0	1,495
Phillippines	240.0	52.2	69.6	362.1	[illegible]	[illegible]	112.0	580.0	610.0	134.0	180.0	974.0
Thailand	173.2	128.6	29.7	331.5	[illegible]	[illegible]	59.0	662.0	690.0	514.0	118.0	1,322
TOTAL FAR EAST	17,175	4,177	1,409	22,755	[illegible]	[illegible]	2,422	35,900	19,221	12,484	4,040	55,745
ALL COUNTRIES STUDIED	22,260	8,246	3,308	33,815	[illegible]	[illegible]	5,555	54,515	53,291	23,768	9,193	86,259

TABLE 10

NUMBER OF DEVELOPING COUNTRIES IN VARIOUS VOLUMES OF FERTILIZER CONSUMPTION

	1980			1990			2000		
	N	P_2O_5	NPK	N	P_2O_5	NPK	N	P_2O_5	NPK
CONSUMPTION T/Y < 50,000	37	37	21	24	29	17	17	21	5
50,000-100,000	10	10	9	11	12	9	9	8	6
100,000-500,000	8	10	10	15	16	21	20	23	28
500,000-1,000,000	6	1	6	4	0	6	4	6	6
1,000,000-5,000,000	1	3	4	5	4	5	9	2	13
> 5,000,000	1	0	2	2	0	3	2	1	3

In 1980, the countries which consumed less than 100,000 T/A of either N or P_2O_5, numbered 47 in a total of 62 countries studied. The number would reduce to 35 in N and 41 in P_2O_5 in 1990. It would further reduce to 26 in N and 11 in P_2O_5 in 2000.

On the other hand, according to the 1980 FAO FERTILIZER YEARBOOK, the 26 Developed Market Economy Countries consumed, in 1980, the following tonnage of fertilizer nutrientes:

N	22.644×10^6	T
P_2O_5	14.249×10^6	T
K_2O	12.779×10^6	T
NPK	49.672×10^6	T

The fact that, in 1980, 49.672 million tons NPK was consumed in 26 Developed Market Economy Countries and 33.815 millions tons of NPK was consumed in 62 Developing Countries analyzed in this study, shows that there must be some fundamental differences in the pattern of supply of fertilizers in these two systems. In other words, the size of the manufacturing plants to produce almost 100 million tons of fertilizers in 26 countries could not have been the same as those used to produce 70 million tons of fertilizers in 62 countries.

3.2. PROJECTION OF FERTILIZER SUPPLY IN DEVELOPING COUNTRIES

There are only two means of supplying a country with fertilizers: internal production or importation.

Internal production of fertilizers, in a general sense, means the transformation of basic raw materials; i.e. carbon or hydrocarbon feedstocks, phosphate rock, sulfur, and potash, into nitro-gen, phosphate and potash fertilizers. If these basic raw materials are not available in a country and are imported as raw materials for internal transformation into fertilizers, the products are still considered as internal production. It is the general tendency to try to use as much as possible locally available raw materials, even if they are of lower grades or are more expensive. By internal production, however, a country needs investing in production facilities so that locally manufactured products can substitute for importation.

If, for many reasons, internal production is not available, fertilizer supply can only be obtained by importation from producer countries, with the expenditure of foreign exchange. Even then, fertilizer processing and marketing facilities must be available for formulation and distribution of fertilizer products. Investments for these facilities, although much lower than production plants, can still be substantial.

3.2.1. ALTERNATIVE I: SUPPLY BY INTERNAL PRODUCTION

Table 11 shows existing production capacity of fertilizers of each country in 1980, and additional capacities necessary between the decades of 1980-1990 and 1990-2000 to meet the demands projected in Table 9. Since muriate of potash is produced only in a limited number of countries, and majority of countries studied need importation for their K_2O supply, production of this nutrient is not considered in this study.

From these estimations, it can be seen that even though the 62 countries in this study already possess 18.8 millions per annum of nitrogen fertilizer production capacity in 1980, in order to meet demand, they need to build new nitrogen capacities of 15.68 million tons per annum between 1980 and 1990, and another 18.7 million tons per annum between 1990 and 2000. They possess 7.6 million tons per annum P_2O_5 capacity in 1980; but they need new P_2O_5 capacities of 7.3 million tons per annum between 1980 and 1990 and 9.2 million tons per annum between 1990 and 2000, if they should opt for internal production to meet their own demands.

3.2.2. ALTERNATIVE II: SUPPLY BY IMPORTATION

In the case of not being able to build more production capacity than they possess in 1980, these countries can only resort to importation for their fertilizer requirements. Table 12 is an estimation of each country's NPK importation requirements in 1980, 1900 and 2000, and the cost in foreign exchange at the price level of 1980. (N and P_2O_5 at $5 per 10 kg unit; K_2O at $2.5 per 10 kg unit).

TABLE II - A

ALTERNATIVE I - SUPPLY BY INTERNAL PRODUCTION:

PROJECTION OF ADDITIONAL PRODUCTION CAPACITIES
FOR FERTILIZERS IN DECADES 80 AND 90
(1000 T/A OF NUTRIENTS)

COUNTRY	1980-1990				1990-2000			
	N		P_2O_5		N		P_2O_5	
	1980	ADDITION	1980	ADDITION	1990	ADDITION	1990	ADDITION
AFRICA								
NW Africa								
Algeria	32	100	63	102	132	137	165	172
Morocco	36.3	163.7	177	0	200	200	160	160
Tunisia	47	11	414	0	58	62	414	0
W. Africa								
Ghana	0	16	0	11	16	16	11	12
Ivory Coast	0	26	0	12	26	26	12	12
Liberia	0	0	0	0	0	0	0	0
Nigeria	0	122	5.2	68	122	122	70	70
Senegal	0	16	25	2	16	16	27	27
Sierra Leone	0	0	0	0	0	0	0	0
C. Africa								
Angola	0	20	0	0	20	20	0	10
Cameroon	0	24	0	11	24	24	11	11
E. Africa								
Ethiopia	0	56	0	107	56	57	107	107
Kenya	0	40	0	40	40	40	40	40
Madagascar	0	0	0	0	0	15	0	0
Malawi	0	30	0	9	30	30	9	9
Mauritius	8.6	10.4	0	9	19	11	9	9
Mozambique	7	16	0	6	23	23	6	6
Zimbabwe	72	17	42	15	89	44	57	29
Tanzania	6.1	41	9.4	1.4	47	47	11	11
Zambia	6.5	81	0	30	87	37	30	30
TOTAL AFRICA	216	790	736	423	1005	977	1139	715
LATIN AMERICA								
C. America								
Costa Rica	40	27	0	22	67	40	22	13
El Salvador	15	69	4	26	84	50	0	18
Guatemala	0	94	5	40	94	57	45	28
Honduras	0	17	0	5	17	10	5	3
Mexico	753	613	250	180	1366	834	430	250
Nicaragua	0	92	0	25	42	25	25	15
Panama	0	20	0	11	20	11	11	6
Caribbean								
Cuba	112	368	14	101	480	290	115	38
Dominican Rep.	0	57	0	29	57	34	29	17

TABLE II - B

ALTERNATIVE I - SUPPLY BY INTERNAL PRODUCTION

PROJECTION OF ADDITIONAL PRODUCTION CAPACITIES
FOR FERTILIZERS IN DECADES 80 AND 90
(1000 T/A OF NUTRIENTS)

COUNTRY	1980-1990				1990-2000			
	N		P_2O_5		N		P_2O_5	
	1980	ADDITION	1980	ADDITION	1990	ADDITION	1990	ADDITION
S. America								
Argentina	25	70	0	95	57	95	95	55
Bolivia	0	0	0	0	0	0	0	0
Brazil	385	915	1620	1130	1300	800	2750	1650
Chile	100	0	30	85	100	40	115	25
Columbia	60	220	50	85	280	168	135	82
Ecuador	0	74	7	45	74	46	52	31
Paraguay	0	0	0	0	0	0	0	0
Peru	74	68	1	25	142	85	26	15
Uruguay	0	32	20	75	32	20	95	29
Venezuela	145	44	23	115	189	111	138	82
TOTAL LATIN AMERICA	1709	2730	2024	2094	4439	2678	4118	2357
NEAR EAST								
Near East Africa								
Egypt	400	423	93	69	823	497	162	100
Lybia	0	41	0	66	41	41	66	66
Sudan	0	0	0	0	0	0	0	0
Near East Asia								
Cyprus	0	21	0	20	21	13	20	12
Iran	71	422	30	286	493	296	316	190
Iraq	355	0	0	53	355	0	53	52
Jordan	0	0	0	0	0	0	0	0
Lebanon	0	35	103	0	35	35	103	0
Saudi Arabia	0	0	0	0	0	0	0	0
Syria	13	137	0	89	150	150	89	89
Turkey	463	800	355	748	1263	758	1103	918
TOTAL NEAR EAST	1304	1879	581	1331	3343	1790	1912	1427
FAR EAST								
South Asia								
Bangladesh	160	350	33	204	510	510	237	238
India	2164	3500	859	807	5666	3400	1666	1000
Pakistan	581	759	58	332	1340	804	390	233
Sri Lanka	0	143	0	59	143	96	59	35
E. & SE Asia								
Burma	60	88	0	63	148	89	63	38
China	10286	3945	2384	1428	14231	5692	3812	2288
Indonesia	982	320	220	90	1300	1300	310	310
Korea DPR	553	222	127	56	775	311	183	74
Korea Rep.	700	20	494	0	720	433	494	65
Malaysia	35	255	27	181	290	174	208	125
Philippines	50	334	37	47	384	226	84	50
Thailand	0	346	37	220	346	264	257	257
TOTAL FAR EAST	15572	10282	4276	3487	25853	13289	7763	4713
ALL COUNTRIES STUDIED	18800	15680	7617	7235	34640	18734	14932	9212

TABLE 12 - A

ALTERNATIVE II - SUPPLY BY IMPORTATION

PROJECTION OF TONNAGE AND FOREIGN EXCHANGE EXPENDITURE

(TONNAGE IN 1000 NPK T/A; EXPENDITURE IN US$ 1000/A)

COUNTRY	1980		1990		2000	
	TONNAGE	EXPENDITURE	TONNAGE	EXPENDITURE	TONNAGE	EXPENDITURE
AFRICA						
NW. Africa						
Algeria	188,4	84,500	255	113,750	501	222,750
Morocco	76.3	28,150	250	102,500	550	230,000
Tunisia	28.9	13,475	65.9	30,975	132	61,950
W. Africa						
Ghana	25.6	9,150	37	16,250	73	32,000
Ivory Coast	44.0	16,250	75	28,250	150	56,500
Liberia	4.7	2,050	9.2	4,025	18.5	8,000
Nigeria	176.7	80,000	227	104,750	454	209,500
Senegal	18	7,250	32	12,000	64	24,000
Sierra Leone	2.5	1,125	6.5	2,900	12.1	5,675
C. Africa						
Angola	16.6	7,250	28.6	13,300	48.6	26,450
Cameroon	21	13,250	57	23,000	114	56,000
E. Africa						
Ethiopia	60	30,000	166	83,000	330	160,000
Kenya	60	27,750	92	42,000	184	84,000
Madagascar	6.8	3,700	17	6,625	34	13,250
Malawi	38.5	18,375	46	21,250	92	42,500
Mauritius	17.4	5,300	44	14,750	77	26,750
Mozambique	21.8	10,300	30.4	13,100	56.8	29,200
Zambabwe	84	21,450	134.8	47,200	230	90,000
Tanzania	20	9,175	48.6	23,400	111.2	53,300
Zambia	68.3	31,750	125.8	60,850	254	121,500
TOTAL AFRICA	980	433,500	1,748	763,875	3,483	1,553,425
LATIN AMERICA						
C. America						
Costa Rica	60.4	23,080	94.8	35,950	173.3	68,325
El Salvador	69.6	15,300	106	50,500	180	86,000
Guatemala	92	41,000	167	85,200	268	121,750
Honduras	30.3	13,300	31.6	13,350	50.6	21,375
México	-	-	-	-	-	-
Nicaragua	64.2	29,800	87	38,500	131	59,500
Panama	30.6	11,600	49.6	20,000	77	31,250
Caribbean						
Cuba	414	160,300	683	277,500	1,197	496,000
Dominican Rep.	86.7	37,750	119	51,250	190	81,750

TABLE 12 - B

ALTERNATIVE II - SUPPLY BY IMPORTATION

PROJECTION OF TONNAGE AND FOREIGN EXCHANGE EXPENDITURE

(TONNAGE IN 1000 NPK/A; EXPENDITURE IN US$ 1000/A)

COUNTRY	1980		1990		2000	
	TONNAGE	EXPENDITURE	TONNAGE	EXPENDITURE	TONNAGE	EXPENDITURE
S. America						
Argentina	88	41,500	177	84,250	303	144.500
Bolivia	5.4	2,400	9.8	5,100	19.8	9.300
Brazil	2,200	770,000	3,500	1,300,000	7,000	2,800,000
Chile	112	51,750	137	63,000	259	120,000
Columbia	196	83,000	435	185.000	760	327,000
Ecuador	86	38,000	154	68,250	251	111,750
Paraguay	6.3	2,800	7.3	3,000	15	6,000
Peru	48.3	20,150	107.9	50,400	215.7	102,180
Uruguay	59.3	28,600	88.4	42,600	130.3	63,325
Venezuela	98.1	36,000	265	106,300	519	218,000
TOTAL LATIN AMERICA	3,748	1,426,330	6,220	2,480,150	11,738	4,886,000
NEAR EAST						
Near East Africa						
Egypt	38.5	7,400	496.5	244,900	1,108	548,900
Lybia	77.7	38,200	109.3	54,075	218.6	108,150
Sudan	80.4	40,000	160	80,000	320	160,000
Near East Asia						
Cyprus	25.2	12,050	44.2	21,230	70.7	33.950
Iran	302	151,000	700	350,000	1,490	594,000
Iraq	25.9	12,300	57.9	27,625	115	55.000
Jordan	13.4	6,350	21.0	9,750	42	19.500
Lebanon	21.6	9,150	47,8	20,700	95.6	41,400
Saudi Arabia	-	-	-	-	-	-
Syria	113.5	56.125	233	115,250	477	235.000
Turkey	923	447.000	1,972	975,000	3.039	1,500,000
TOTAL NEAR EAST	1,600	779.575	3.842	1,898.530	6.975	3,295.900
FAR EAST						
South Asia						
Bangladesh	277	131,500	604	289,130	1,401	675.200
India	2.759	1,180,000	5,196	2,375,800	10,129	4,708.500
Pakistan	712	350,000	1,104	548,830	2,150	1,069.500
Sri Lanka	150	66,250	259	115,250	414	184,250
E. & SE Asia						
Burma	53.5	25,875	158	77,450	289	141,750
China	-	-	-	-	-	-
Indonesia	308	112,675	696	301,500	2,390	1,102.500
Korea DPR	-	-	-	-	-	-
Korea Rep.	170	42,500	312	78,000	499	124,750
Philippines	320	140,100	493	218,500	837	373,500
Thailand	318	150,750	625	297,750	1,285	613,000
TOTAL FAR EAST	5,068	2,196,650	9.447	4,302.210	19,394	8,992.950
ALL COUNTRIES STUDIED	11,396	4,836,055	21,257	9,444,765	41,590	18,728,275

On examining Table 12, it can be seen that importation of the 62 countries would have doubled every ten years, if no attempt is made to produce fertilizers internally. If this should happen, there could well be further aggravation of the situation for themselves because buying such large quantities of fertilizers from producer countries would surely cause escalation of prices.

Evidently, what iil probably happen would not be the whole of either of the two alternatives. The option for internal production relys the influence of many other factors the most important of which must always be the political one. Even if the alternative of internal production is chosen and implanted, it will not eliminate totally foreign exchange expenditures. For most countries, the importation of phosphate rock, sulfur, potash, and even some form of carbon or hydrocarbon feedstocks will continue to be necessary. It would, however, diminish substantially the total requirement of foreign exchange. What is more important, it would contribute positively to the general economy of the country by providing employments, by paying for local goods and services, and by generating many other benefits to the society as a whole.

4. MARKET FOR MINI-FERTILIZER PLANTS IN DEVELOPING COUNTRIES

4.1. SCOPE OF MINI-FERTILIZER PLANTS

Mini-fertilizer plants can be defined as a group of fertilizer manufacturing and processing units which are adaptable to the conditions and dimensions of developing fertilizer markets.

Most of the developed countries had been through the stage of employment of mini-fertilizer plants thirty or forty year ago. Even to-day, some of those installations co-exist with the modern large scale plants. The fact that more than 13 million tons of single superphosphate is still being made in the developed countries in 1980 testifies to the continued usefulness of mini-fertilizer plants even in developed countries. For agronomical, economical and logistical reasons, there is no complete substitution of mini-fertilizer plants by macro-fertilizer plants under some special circumstances.

Several developing countries, notably China, India and Brazil, have reached a substantial level of fertilizer production by the employment of mini-fertilizer plants during the past two decades. All of them have now passed the market dimension of that can better be attended by mini-fertilizer plants. Nevertheless, those mini-fertilizer plant are, and will be for many years to come, the basis of their fertilizer industry. China, for example, has been concentrating on the building of 1000 T/D ammonia plants. But those 1400 existing mini-ammonia plants are still the backbone of their N production. Through expansion and improvement of these plants will come a major part of additional capacity of the future.

In the coming two decades, when most of those developing countries which consumed less than 500,000 tons nutrients per annum start the process of developing internal fertilizer production capacities, mini-fertilizer plants would be used, in the majority of cases, as the principal instrument for this purpose. In due course of time, these mini-fertilizer plants will have outrun their usefulness as they laid the foundation of the developing fertilizer industry in those countries. But they will continue to play their role, just as they are playing now in the developed countries, and in the more advanced of the developing countries.

In order to confine the scope of mini-fertilizer plants to the essential parameters which a developing fertilizer industry must have from the beginning, three groups of plants and installations are identified.

4.1.1. NITROGEN FERTILIZER PLANTS

Nitrogen fertilizers being the highest volume fertilizer nutrient consumed in the developing conntries, nitrogen fertilizer production plants are undoubtedly the most important of all mini-fertilizer plants. Nitrogen fertilizer plants consist of two components: the synthetic ammonia unit and the nitrogen fertilizer production unit.

For the purpose of meeting nitrogen fertilizer demands of various dimensions of developing fertilizer markets, ammonia synthesis plants of 50, 100 and 200 tons ammonia per day capacities are chosen in this study. This does not prevent any intermediary capacity plant being considered in a particular case. It is thought, however, that if mini-fertilizer plants in large numbers are to bring any benefit to the fertilizer industry of the developing countries in terms of cost of implantation, they must be standardized. A survey of small ammonia synthesis plants which had been built during the past two decades indicates that they fall into these three dimensions.

As a rule, ammonia synthesis plant in a developing country is accompanied by a downstream nitrogen fertilizer plant. Although there are many options in the final product to be obtained from ammonia, there is a preference for urea because of its high concentration and ease of handling and transportation However, during the last twenty years, ammonium bicarbonate has developed in China as an important nitrogen fertilizer. Experience in China has demonstrated that lower investment and production costs in the manufacturing of ammonium bicarbonate seem to compensate for its low concentration. In this study, ammonia plants of 200 T NH_3/day can have the option of being coupled with either an urea plant or an ammonium bicarbonate plant. The smaller ammonia plants, of 50 to 100 T NH_3/day, are adapted with ammonium bicarbonate units. This does not preclude any other type of nitrogen fertilizer from being considered. For a country which contemplates the production of nitrogen fertilizers, ammonia plant is the fundamental, the other secondary.

4.1.2. PHOSPHATE FERTILIZER PLANTS

In spite of the fact that concentrated phosphate fertilizers such as TSP and DAP have already become standard fertilizer inputs in many developing countries which have been depending on importation as their source of fertilizer supply, single superphosphate would still be the phosphate fertilizer to be produced at the initial stage of a country's attempt at internal production.

The production of single superphossphate in a developing country usually requires the manufacturing of sulfuric acid. Three scales of sulfuric acid plants, 50, 100 and 200 tons per day of 98 % or 94 % sulfuric acid, coupled with superphosphate plant of up to 500 T/Day capacity consist of the mini-phosphate fertilizer plants considered in this study. Other more concentrated fertilizers, such as concentrated superphosphates and ammonium phosphates, require the use of phosphoric acid. Phosphoric acid can be produced in small units. But for the purpose of phosphate fertilizer production in most developing countries, it is doubtful whether it is advisable to go into concentrated fertilizer manufacture at the initial stage of the process of development of the fertilizer industry.

4.1.3. INSTALLATIONS FOR FERTILIZER PROCESSING AND MARKETING

In most of planned economy countries, the fertilizer industry is not necessarily involved in the formulation, and marketing of fertilizer products. In most of the market economy countries, however, installations and facilities to elaborate the final products, to store raw materials and finished or semi-finished products, and to distribute the final products to the farm gate, are integrated parts of the industry. There are no standardized processes, equipment, or installations. They can be very simple hand operated bulk blending machines. They can also be very complicated and sophisticated granulation plants. The in-plant storage space can be simple covered sheds; they can also be mechanically operated bulk storages of up to 100,000 ton capacity. Fertilizer being a seasonal commodity, final products in the marketing pipeline in preparation for peak season delivery can be as much as one third of the annual output. Therefore, infrastructure for marketing purposes can be extensive and also capital intensive.

When a fertilizer operation reaches a certain throughput, these installations become a necessary part of the whole plant. For the purpose of this study, a group of installations which can blend, granulate and handle 100,000 tons product per year for marketing is considered as a basic unit. The granulation installation can also be considered as an anticipated investment for its future utilization as binary and compound fertilizer production unit. Coupled with this processing unit, storage facilities for processing and marketing purposes are considered as auxiliary installations in the some integrated unit.

4.2. POTENTIAL MARKET FOR MINI-FERTILIZER PLANTS

In the previous chapter (3.2.1. Table 11) an estimation was made as to the additional fertilizer production capacity which a country would need to be implanted during the periods of 1980-1990 and 1990-2000, if it were to opt for internal production to meet the expanded demand of fertilizers. An estimation of the number of each type and size of mini-fertilizer plants which would be needed to enable each country to provide that additional fertilizer production capacity will indicate the potential market dimension of those mini-fertilizer plants.

Table 13 shows the result of such an estimation. During the decade of 80, and 90, if all these 62 countries studied here are to produce internally the additional nitrogen and phosphate fertilizer requirements, they need to build the following plants:

TABLE 13 - A

MARKET POTENTIAL OF MINI-FERTILIZER PLANTS IN THE DEVELOPING COUNTRIES

COUNTRY	1980-1990							1990-2000						
	N-FERTILIZER MINI-PLANTS			P-FERTILIZER MINI-PLANTS			PROCESSING + MARKETING FACILITIES	N-FERTILIZER MINI-PLANTS			P-FERTILIZER MINI-PLANTS			PROCESSING + MARKETING FACILITIES
	50T/D NH_3	100T/D NH_3	200T/D NH_3	50T/D H_2SO_4	100T/D H_2SO_4	200T/D H_2SO_4		50T/D NH_3	100T/D NH_3	200T/D NH_3	50T/D H_2SO_4	100T/D H_2SO_4	200T/D H_2SO_4	
AFRICA														
NW. Africa														
Algeria			4			6	6			6			10	10
Morocco			8							10				10
Tunisia			2				4			2				8
W. Africa														
Ghana	2			2				2			2			
Ivory Coast		2		2					2		2			
Liberia														
Nigeria			4			4	8			4			4	8
Senegal									2			2		2
Sierra Leone														
C. Africa														
Angola		2							2		2			
Cameroon		2		2			2		2		2			2
E. Africa														
Ethiopia			2			2	2			2			2	2
Kenya			2			4	4			2			4	4
Madagascar								2						
Malawi		2		2					2		2			
Mauritius	2			2			2	2			2			2
Mozambique	2			2				2			2			
Zimbabwe								2					2	
Tanzania			2							2		2		2
Zambia			4			2	2			4			2	2
TOTAL AFRICA	8	8	28	12	0	18	30	10	10	32	14	4	24	52
LATIN AMERICA														
C. America														
Costa Rica		2			2		2			2		2		2
El Salvador			2			2	2			2			2	2
Guatemala			4			2	2			2			2	2
Honduras	2			2	2			2						
Mexico *			•				•			•			•	
Nicaragua			2			2	2		2			2		2
Panama		2					2		2					
Caribbean														
Cuba *			•			6				•			2	
Dominican Rep.			2			2	2			2			2	2

* Needs new macro-fertilizer plants.

TABLE 13 - B

MARKET POTENTIAL OF MINI-FERTILIZER PLANTS IN THE DEVELOPING COUNTRIES

COUNTRY	1980-1990							1990-2000						
	N-FERTILIZER MINI-PLANTS			P-FERTILIZER MINI-PLANTS			PROCESSING + MARKETING FACILITIES	N-FERTILIZER MINI-PLANTS			P-FERTILIZER MINI-PLANTS			PROCESSING + MARKETING FACILITIES
	50T/D NH_3	100T/D NH_3	200T/D NH_3	50T/D H_2SO_4	100T/D H_2SO_4	200T/D H_2SO_4		50T/D NH_3	100T/D NH_3	200T/D NH_3	50T/D H_2SO_4	100T/D H_2SO_4	200T/D H_2SO_4	
S. America														
Argentina		4				6	6		4				4	
Bolivia														
Brazil*			3			*5				10			*10	
Chile			2			6	6						6	2
Colombia			10			5				6			6	
Ecuador			4			4	2			2			4	2
Paraguay														
Peru		2	2			2	4			4	2			4
Uruguay		2				2					2	2		
Venezuela			2			8	8			4			8	4
TOTAL LATIN AMERICA	2	12	33	2	4	56	32	2	8	34	2	3	46	26
NEAR EAST														
Near East Africa														
Egypt *			*			4	4			*			6	6
Lybia			2			4	4			2			4	4
Sudan														
Near East Asia														
Cyprus		2			2		2					2		
Iran *			*							*				
Iraq *			*			4	4			*			4	4
Jordan														
Lebanon			2						2					
Saudi Arabia														
Syria *			*			6	6			*			6	6
Turkey *			*							*				
TOTAL NEAR EAST	0	2	4	0	2	18	20	0	2	2	0	2	20	20
FAR EAST														
S. Asia														
Bangladesh *			10			12	12			*			14	14
India *			*			*	44			*			*	76
Pakistan *			20			20	20			*			14	14
Sri Lanka			6			4	6			6			3	3
E. & SE. Asia														
Burma		6			8		8		6			4		6
China *			*			*				*			*	
Indonesia			10			6	16			10			6	18
Korea DPR			8			4				12			4	
Korea Rep.*			*							*				
Malaysia			10			10				6			8	8
Philippines			12			6	6			8			6	6
Thailand			14			14	14			10			14	14
TOTAL FAR EAST	0	6	90	0	8	76	136	0	6	52	0	4	79	163
ALL COUNTRIES STUDIED	15	28	155	14	14	168	218	12	26	120	16	12	160	258

* Needs new macro-fertilizer plants

	1980-1990	1990-2000
NITROGEN FERTILIZER PLANTS		
50 T/D NH_3 plants	5	6
40 TN/D N plants	5	6
100 T/D NH_3 plants	14	13
80 TN/D N plants	14	13
200 T/D NH_3 plants	79	60
160 TN/D N plants	76	60
TOTAL NH_3 + N plants	193	158
PHOSPHATE FERTILIZER PLANTS		
50 T/D H_2SO_4 plants	7	8
120 T/D SSP plants	7	8
100 T/D H_2SO_4 plants	7	9
250 T/D SSP plants	7	9
200 T/D H_2SO_4 plants	84	80
500 T/D SSP plants	84	80
TOTAL H_2SO_4 + SSP plants	196	194
PROCESSING PLANTS	109	129
STORAGES ETC	109	129

The task of building such a large number of mini-fertilizer plants in 20 years may seem formidable. Looking at the experience of China, however, it would seem to be highly feasible. Between 1958 and 1980, China built 1400 synthetic ammonia plants ranging from 50 to 1000 T/D NH_3 in capacity. They also built 700 phosphate fertilizer plants, mostly single superphosphate plants provided with captive sulfuric acid production. Building 177 ammonia plants, 174 nitrogen fertilizer plants, 195 sulfuric acid plants, and 195 superphosphate plants, in twenty year should not be an insurmontable task, considering that many countries have already acquired the experience and possess the capacity to realize such an undertaking.

Fertilizer processing plants and storage facilities are not fertilizer production units. But they are essential components of the fertilizer sector. The estimated number of installations which may be necessary in the developing countries in decades 80 and 90 is only meant as an indication that such substantial investments are necessary in parallel with the fertilizer production plants. To demonstrate that such a task is not without precedent, it can be mentioned that in the U.S.A. 120 granulation plants of 20-50 T/Hr capacity had been built in the decades of 50 and 60 for processing intermediate raw materials into compound fertilizers. There are in the U.S.A. over 2000 fertilizer distribution operations, each having a yearly delivery volume of 5000 to 10.000 tons products. In these distribution centers, bulk blending machines and storage capacities of 2000 to 3000 tons of raw materials and intermediates are usually provided.

To build this number of plants and installations would probably require the investment of the following sums:

	1980-1990 ($ 1×10^6)	1990-2000 ($ 1×10^6)
N - Fertilizer Plants *	5,090	4,015
P - Fertilizer Plants *	1,855	1,815
Processing + Marketing	1,090	1,290
T O T A L	8,035	7,120

* Battery limit costs

These estimations are limited to the potential market of mini-fertilizers plants. There are many developing countries where development of the fertilizer industry has advanced, volumewise, to such a stage that mini-fertilizer plants would no longer be economically viable, principally for reasons of economy of scale. China and India are two of the more prominent examples in this respect. Eventually, most of the developing countries would find themselves in this situation. Before that situation arises, however, mini-fertilizer plants will be playing their role as the more viable source of fertilizers for the developing countries. Also, once implanted, they will keep on their usefulness for a long time to come.

4.3. Factors Favouring the Implantation of Mini-Fertilizer Plants

4.3.1. FERTILIZER MARKET SIZE AND DENSITY Vs FERTILIZER PLANT CAPACITY

It is a generally accepted premise that a basic fertilizer raw material plant should try to take advantage of the economy of scale. This premise may not be valid or practical under the conditions of many developing countries. In the first place the dimension of the fertilizer market in most developing areas would rarely be sufficient for large sized plants. In the second place, the low density of the fertilizer market in most developing countries usually favour decentralization with several smaller sized production plants, instead of concentrated production in one large sized plants.

Of the 62 developing countries studied, only 16 exceeded annual consumption of 100,000 tons N in 1980. 14 exceeded 100,000 t/a in P_2O_5. If no production facilities existed before in those countries, two 200 t/d NH_3 plants and three 200 t/d H_2SO_4 plants, together with equivalent N and P_2O_5 fertilizer plants, will provide 100,000 t/a of N and an equal amount of P_2O_5. This demonstrates that, at this stage of development, mini-fertilizers plants, as conceived in this project, are better suited to the nea ds of the developing countries.

4.3.2. LOGISTICS OF FERTILIZERS

There are two logistical systems involved in the process of supplying fertilizers to the farm gate, beginning from the source of basic raw materials. First, by the nature of highly concentrated occurances in widely spreaded out geographical locations of basic fertilizer raw materials, which include carbon, hydrocarbon, phosphate rock, sulfur and potash, a logistical system has heen structured to collect and move these industrial inputs from the points of occurance to the points of industrialization. Because of large volume, low per unit value, comparative insensibility of these materials to atmospheric exposure, and ready susceptibility to mechanical handling, this part of logistical expenditure per unit is usually very low.

From the point of industrialization of fertilizers to the farm gate or into the soil, the logistics involved is quite different from the former one. Firstly, there is a substantial reduction in order of magnitude. Whereas the movement to the point of industrialization is usually accomplished in hundreds and thousands of tons; that coming out from this point would be in carloads or truckloads. The added value of this material, now in the form of products, would be more sensitive to atmospheric conditions, to handling and to loss. Logistical problems are further compounded by the seasonal nature of fertilizer marketing. Since fertilizer is actually applied on the soil in a period of about 100 days per year, this high concentration of demand influences profoundly the logistics system. Logically, the most economical system would be to load fertilizer products at the point of production, and discharge directly at the point of application. An overwhelmingly large percentage of fertilizer consumption in developing countries being in bags, this direct loading and discharging, if practised, would bring an appreciable economy in overall cost. Practically, however, only a fraction of fertilizer delivery can be made during this short period of application. For reasons of spreading out the period of delivery, and of greater assurance to the farmer to have fertilizers on hand at moment of application, fertilizers usually go through several stages of transport and handling before application. In a country of less developed infrastructure, this operation can increase the overall cost considerably.

This clear division of logistical structure in the fertilizer sector of the economic system of a country at the point of industrialization usually favour the localization of industries, at points as near as possible to the final points of consumption. To less developed areas, this favours the installation of mini-fertilizer plants in greater numbers, each to serve a limited market area, instead of one large scale plant to serve a widely spreaded out market.

During the last two decades, there has been a tendency in some raw material producing areas to capitalize on this structure of the fertilizer sector by up-grading their raw materials in large scale, taking advantage of economy of scale, and sending the up-graded raw materials, mostly anhydrous liquid ammonia and phosphoric acid, to many points of industrialization by a new large volume and low cost logistical systems, the tankers. This system, while quite responsive to a rapidly expanding and large volume fertilizer market, may not be the solution, in long range terms, for many developing countries. Firstly, upgrading must mean, in the end, higher cost. Secondly, the employment of big volume tankers does not necessarily mean an overall lowering of logistical cost up to the point of industrialization. The infrastructures to handle, move, and store ammonia, either under pressure or at low temperature, and merchant phosphoric acid, in acid proof agitated tanks, are so sophisticated and capital intensive that few emerging fertilizer market could cope with in the initial phase of their attempt to supply their fertilizer requirements by internal production.

4.3.3. SAVINGS IN FOREIGN ENCHANGE

Rare is the country, developed or developing, which possesses raw materials for all three macronutrients. Complete self-sufficiency in fertilizer production, therefore, is not easily achieved. For many of the developing countries which do not possess any basic fertilizer raw materials, it is some times thought that it might be more economical to import fertilizer products, instead of importing raw materials and have them converted into products internally.

Irrespective of the final cost to the farmer of the imported or internally produced fertilizer products, the difference in foreign exchange content of the two alone would usually favour decision for the latter. Except for a few of the OPEC countries, unfavourable balance of payment has always been a problem in most developing countries. Lowering of foreign exchange requirement for importation is always desirable.

Take phosphate fertilizer for example. The final phosphate fertilizers imported by developing countries in 1980 averaged \$ 5 per unit P_2O_5 of 10 kg, or \$ 500 por ton of P_2O_5. Phosphate rock averaged \$ 1 per unit of P_2O_5 FOB and about \$ 1,8 per unit C & F to most countries. This does not mean a reduction of P_2O_5 fertilizer cost to the consumer of these countries. It is of importance to those countries, however, that on this account, the foreign exchange requirement can be reduced 60 % by importing only raw materials to be processed into fertilizers.

4.3.4. INTERNAL ECONOMIC GAINS

It has been the general tendency in most countries to produce internally, whenever possible, some of the primary inputs to its economy. It is observed that internal fertilizers production is practically universal in the major food producing countries. Not only a large portion of foreign exchange is saved, in the case of importation of fertilizer raw materials being inevitable, but also the rest of the cost of industrializati and marketing is spent internally. This expenditure will generate a whole series of benefits which would be added to the general economy of the country.

4.4. CONSTRAINTS FOR THE IMPLANTATION OF MINI-FERTILIZER PLANTS

4.4.1. TECHNICAL AND ECONOMIC TRAINTS

Production of fertilizers in a country usually starts when the economic development of that country has reached such a level that there is no problem of basic industrial infrastructure. Otherwise, some other more urgent priorities must be met first before production of agricultural inputs like fertilizer can be considered.

In practice, if this minimum level of development does not exist, there will not be sufficient technical capability to enter into a more advanced or sophisticated industrial activity like that of fertilizer production. Of course many constraints of this nature can be overcome during a short period of time if there is enough urgency and incentive for the country to do so. Then there would be trade-off of time gain with added cost.

4.4.2. FINANCIAL CONSTRAINTS

In a market economy, the fertilizer industry is usually in the hands of the private sector. That being so, financing of a comparatively capital intensive investment as the fertilizer industry is usually difficult, unless there is intervention by the government. The difficulty is further compounded by the high level working capital requirements of the industry because of the seasonal nature of the fertilizer market. Again, this type of problem can either be solved through interference of the government, or at the expense of thefinal cost of products.

4.4.3. POLITICAL CONSTRAINTS

In the final analysis, all economic activities, no matter what political system it may be, are subject to the direct influence of political will. Increasing food production is one of the basic economic priorities of most countries, especially the developing countries. Only political will, however, can channel resources for its realization. Fertilizer production being one of the more important instruments for increasing food production, whether the supply of fertilizers will be obtained from building of adequate numbers of fertilizer plants, or by direct importation of fertilizer products, is mainly a political decision.

This political influence on the economic sector in any country can be made through various means. In food production, for example, incentives through floor prices, through subsidies, or through fiscal compensation mechanisms have been used in many countries as means to increase production. In fertilizer production, subsidies in the price of fertilizers, low interest financing of investments, and management of importation through custom tariffs have been used in many countries to encourage the implantation of industry.

As examples, the cases of China and Brazil can be cited as illustrative, if not typical. In China, it was decided by the government in 1958 that fertilizer plants be built to provide fertilizers for increasing agricultural productivity and expanding food production. Twenty two years later, in 1980, China possesses 1400 nitrogen fertilizer plants and 700 phosphate fertilizer plants, a great number of which could be classified as mini-fertilizer plants. China through this policy, became the third producer of fertilizer of the world and is practically self-sufficient in fertilizer requirement.

In Brazil, an incentive policy in agriculture was formed and conducted from 1965 to subsidize the purchase of agricultural inputs, such as fertilizer. As a consequence, it launched the continued high growth rate of fertilizer consumption in Brazil for 15 years. Coupled with a policy of promoting indigenous production of fertilizers through fiscal incentives and tariff manipulation, Brazil is well on the way to self-sufficiency in fertilizers. Unlike China, Brazil's fertilizer industry being mostly in the hands of the private sector, its development has been concentrating in the areas of processing and marketing, with the result that dependence on imported ammonia and phosphoric acid will persist for some time to come. Eventually, dependence on these raw materials will diminish. Meanwhile, foreign exchange requirement for the importation of raw material has already been reduced to 50% of what would have been necessary if Brazil had not made the effort to develop its fertilizer industry.

5. CONSIDERATIONS ON THE FEASIBILITY OF IMPLANTING MINI-FERTILIZER PLANTS IN DEVELOPING COUNTRIES

From data and projections derived and analyzed in this study, conclusions could be reached that: substantial quantities of fertilizers will be required to help increase food production in the developing countries in the coming decades; for those countries which have not, so far, developed adquately their fertilizer production capacity, building up new fertilizer production capacity seems to be the only alternative available for them; and mini-fertilizer plants would fit into their requirements at this stage of development.

When translating these generalities into specifics, it will become apparent that no two conditions are completely identical. What may have been viable for one country or one determined area of one country may not be so for another one. Since it is the purpose of this project to identify, to specify, to inform and in the end to help some of the developing countries, should they need it, to engagge in the process of implantation of mini-fertilizer plants, it seems fit to define here some of the common parameters which would make the mini-fertilizer plants in general more feasible under diversas conditions of the developing countries who intend to build them.

5.1. TECHNICAL CONSIDERATIONS

5.1.1. PRODUCT-MIX

It is a generally recognized phenomenon that fertilizers came into being through the capability of the chemical industry to produce, and not through delibrate design from agronomical requirements. A market, especially a developing country fertilizer market, accepts what is available, not what might be better for their agronomical needs. What is more, once a product is introduced and accepted in a market, it will be difficult to change into another one even though the other may be superior agronomically.

It is the general tendency for a new-comer in the fertilizer industry to start with an "advanced" produc-mix. However, in determining a product-mix for production in a developing country, which has already been using imported "advanced" high concentration fertilizers, it may be helpful to point out how those fertilizers came into being. For example, high concentration fertilizers such as triple superphosphate and diammonium phosphate had become a necessity when the application rate of fertilizers increased so much that logistics alone would make low concentration fertilizers economically at a disadvantage. The average fertilizer application rate in developed countries was abont 127 kg NPK or 280 kg fertilizers per annum per hectare of arable land and permanent crops; whereas the average in developing countries was 31 kg NPK or not more than 80 kg fertilizers of the same concentration. Thus, it would seem to be more logical if low concentration fertilizers like ammonium bicarbonate and single superphosphate be considered as a basic product-mix for production in a developing country where fertilizer use is still in its initiel stage.

It is recognized that, in a market economy, decisions of this kind is usually made by the marketing sector of the industry. Rarely would a vender opt for a simpler but adequate product, if he is used to a higher value up-graded but more expensive product. On the other hand, even if the decision is to be a technical one, it may be difficult to arrive at an agreement between the chemical and the agronomical. This will perhaps be the key decision for the implantation of mini-fertilizer plants when a developing country starts the process of internal fertilizer production. It also promises to be a difficult one.

5.1.2. TECHNOLOGY

There has not been any basic breakthrough in fertilizer process technology during the past half a century. There have, however, been many refinements and innovations. There are several notable landmarks in technology improvement. The double contact and double absorption in contact sulfuric acid process; the use of centrifugal compr-essor in large synthetic ammonia units; the integrated neutralization and granulation of ammonium phosphate are some of those key improvements.

Since all mainstream fertilizer processes follow identical basic flowsheets, differences in a vast number of technologies are mostly of a physical nature such as temperature, pressure, catalyst composition and physical state, and means of flow and transference of materials.

Choice of technology for the mini-fertilizer plants destined for developing countries is, at best, a haphazard undertaking, in view of the wide variety of availability of raw materials, and the diversity of environment in each country. There are, however, a number of guidelines which can be followed in such a task.

First of all, any chosen technology to be used in a developing environment must be tried and proven. Furthermore, what is tried and true in one group of countries does not automatically become the same in another. In the evaluation of technical fea-sibility of a process in a developing country, it is important that every aspect of the developing country's existing technical and economic environments, such as infrastructure, availability and quality of technical personnel, be taken into consideration.

Simplicity in construction as well as operation is a point not well appreciated by many people in the fertilizer industry. Sophistication is usually designed for enlarged scale, economy of labour and improvement of quality. Since none of these factors is particularly relevant in the mini-fertilizer plants dealt with here, simplicity should be emphasized whenever possible.

Energy conservation is important in fertilizer plants, especially synthetic ammonia plants. However, energy conservation measures must be compatible with the additional investments involved to get a optimum benefit. In phosphate fertilizer production plants, the heats of reaction of the chemical processes, be it the formation of monocalcium phosphate in the superphosphate process, be it the formation of ammonium phosphates, should be made use of rationally to obtain finished products without using additional external heat.

Adherance to the norms practiced in the developed countries should be reexamined to correspond to the interests of the developing countries. In many cases, those norms exist for commercial reasons to protect the vested interests of the industry. For example, if a local phosphate rock cannot be up-graded without excessive investment and high loss of P_2O_5 during the process of beneficiation, a lower grade of superphosphate than the accepted norm in developed countries should be allowed to be produced and marketed.

5.2. Economic Considerations

5.2.1. STANDARDIZATION OF OF MINI-FERTILIZER PLANTS

One of the basic concepts of this project is to try to help developing countries who need building mini-fertilizer plants to obtain an economy in unit cost of the plants by the large number of plants to be implanted, as a trade-off for economy of scale. This purpose can only be achieved by standardization.

Standardization begins with a freezing of process and design, continues in a modular construction of interchangeable and multipliable units and ends up with flexibility and adaptability to local conditions. Standardization eliminates repetitive engineering expenses and avoids "one-of-a-kind" construction of machinery and equipment.

Standardization usually shortens substantially the lead time by eliminating many time-consuming steps in the process of implantation.

5.2.2. ECONOMY IN INVESTMENT AND LOWERING COST OF PRODUCTION

Capital for investment is usually a scarce commodity in a developing country. Therefore a better allocation of available resources should be aimed at in implanting mini-fertilizer plants in developing countries. Simplicity in basic engineering, standardization of battery limit supply, rationalization and economy in off-site construction, and readiness to accept labour intensive processing instead of capital intensive labour saving installations would go a long way to reduce investment cost as well as operational cost. Not enough attention is usually paid to the fact that when a substantial part of the investment is borrowed capital, financial cost can be a heavy burden.

5.2.3. TOWARD RATIONALIZATION OF CRITERIA IN FEASIBILITY STUDIES FOR THE IMPLANTATION OF MINI-FERTILIZER PLANT IN DEVELOPING COUNTRIES

When decision for the implantation of a project is not taken politically, an economic decision is usually reached basing on a feasibility study. Feasibility studies have become so standardized and parameters so narrowly limited that they may not attend to the need of viewing toward a broader horigon in economic decisions in a developing country. Under the conditions of the market economy developed countries, the feasibility of an enterprise depends strictly on its ability to generate profit, in competition with other enterprises of the same nature under the same conditions. In a developing country, benefit and cost relationship should be broadened to cover a wider horizon of the economy. For example, if a local raw material is of a lower grade and unit cost is higher than imported, a narrow criterion would probably veto its employment. But the employment of the local material would generate economic benefits related to its spere of influence so that overall benefits to the economy will be positive.

Another example could be cited in the case of low concentration fertilizers. It is generally claimed that the inert material in the low concentration fertilizer means higher transport cost per unit of nutrient applied to the soil. But that extra freight is not lost in the overall economy. It generates benefits in the transport sector and contributes to the economy in general.

Lastly, foreign exchange expenditure has rarely been an issue in feasibility studies in developed countries. In a developing country, balance of payment can be a very serious problem. Therefore, if foreign exchange expenditure cannot be totally avoided for the importation of fertilizers, at least the saving of a part of foreign exchange should be tried. This can only be achieved by investing in internal fertilizer production.

ANNEX

I SUMMARY OF VITAL STATISTICS;
FERTILIZER DEMAND AND SUPPLY PROJECTIONS;
MINI-FERTILIZER PLANTS REQUIREMENT AND INVESTMENT
ESTIMATIONS; OF 62 DEVELOPING COUNTRIES

COUNTRY	POPULATION (1000) 1980	PER CAPUT GDP (1975 $) 1980	PER CAPUT CEREAL PRODUCTION (KG/A) 1980	PER CAPUT NUTRIENT CONSUMPTION (KG $N+P_2O_5+K_2O$/A) 1980	1990	2000	TOTAL FERTILIZER NUTRIENT CONSUMPTION (T/A $N+P_2O_5+K_2O$) 1980	1990	2000
AFRICA									
NORTHWEST									
LGERIA	18,337	1,065	120	9.6	13.6	22.5	176,000	352,000	710,000
OROCCO	20,384	462	230	11.0	16.3	25.3	226,300	452,600	910,000
UNISIA	6,651	899	182	9.7	14.8	23.6	63,650	127,400	255,200
WEST									
HANA	11,446	540	50	1.6	2.3	3.5	18,313	36,630	73,000
VORY COAST	5,577	960	164	6.7	10.2	15.6	37,370	74,800	149,600
IBERIA	1,937	512	125	2.3	3.7	6.5	4,550	9,350	18,620
IGERIA	87,112	341	107	1.3	1.8	2.8	113,267	226,600	453,000
ENEGAL	5,635	309	142	5.3	8.1	12.7	25,276	58,552	117,000
IERRA LEONE	3,352	276	125	0.8	1.4	2.2	2,720	6,100	10,100
ENTRAL									
NGOLA	7,181	545	56	2.0	3.1	4.6	14,358	28,716	57,432
AMEROON	7,688	492	132	4.0	6.5	10.2	29,040	58,140	116,006
EAST									
THIOPIA	31,522	104	148	2.6	4.0	6.1	81,960	163,920	327,086
ENYA	15,608	256	165	2.8	4.2	5.5	46,240	92,700	185,400
ADAGASCAR	9,329	235	265	0.9	1.3	1.8	8,350	16,700	33,700
ALAWI	5,577	156	228	4.1	6.3	9.7	23,080	46,000	92,000
AURITIUS	569	715	-	27.6	48.0	60.3	26,740	53,500	106,600
OZAMBIQUE	10,375	454	46	1.7	2.8	4.3	28,500	57,000	114,000
IMBABWE	7,455	495	272	16.8	16.5	18.9	125,940	169,000	203,000
ANZANIA	18,052	188	80	1.7	2.5	3.7	30,700	61,400	122,800
AMBIA	5,075	462	154	10.8	15.3	21.7	62,900	126,800	251,600
OTAL AFRICA							1,149,425	2,238,108	4,386,052
ATIN AMERICA									
ENTRAL									
OSTA RICA	2,286	1,025	124	36.6	45.4	58.2	83,700	134,000	213,500
L SALVADOR	4,813	484	160	16.6	18.7	22.6	77,560	124,000	198,000
UATEMALA	7,180	645	178	15.1	18.3	22.4	107,900	172,600	276,400
ONDURAS	3,595	351	120	5.5	6.4	7.4	19,740	31,600	50,600
EXICO	69,965	1,375	278	16.9	19.4	23.8	1,182,500	1,992,000	3,028,000
ICARAGUA	2,733	718	135	20.0	23.1	25.5	54,900	87,900	131,700
ANAMA	1,930	1,458	137	15.7	19.2	23.9	30,400	48,700	77,000

COUNTRY	ALTERNATIVE I: SUPPLY BY INTERNAL PRODUCTION — NEW PRODUCTION PLANTS AND FACILITIES REQUIREMENT: NITROGEN FERTILIZER MINI-PLANTS 1980-1990	1990-2000	PHOSPHATE FERTILIZER MINI-PLANTS 1980-1990	1990-2000	FERTILIZER PROCESSING PLANTS & FACILITIES 1980-1990	1990-2000	ESTIMATED INVESTMENTS (US$ 1000) 1980-1990	1990-2000	ALTERNATIVE II: SUPPLY BY IMPORTATION — TONNAGE OF IMPORTS ($N+P_2O_5+K_2O$ T/ANNUM) 1980	1990	2000	FOREIGN EXCHANGE REQUIREMENT (US$ 1000/ANNUM) 1980	1990	2000
AFRICA														
NORTHWEST														
LGERIA	4	6	6	13	6	10	210,000	330,000	188,400	255,000	501,000	84,500	113,750	222,
OROCCO	8	10	-	-	-	10	240,600	350,000	76,300	250,000	550,000	38,150	102,500	230,
UNISIA	2	2	-	-	4	8	80,000	100,000	28,500	65,900	131,000	13,475	30,975	61,
WEST														
HANA	2	2	2	2	1	1	30,000	30,000	25,600	37,000	73,000	9,150	16,250	32,
VORY COAST	2	2	2	2	1	1	40,000	40,000	44,000	75,000	150,000	16,250	28,250	56,
IBERIA									4,700	9,700	18,500	2,052	4,025	8,
IGERIA	4	4	4	4	8	8	200,000	200,000	174,700	327,000	454,000	80,052	184,750	205,
ENEGAL	2	2	-	2	-	2	15,000	55,000	18,000	32,000	64,000	7,250	12,600	24,
IERRA LEONE	-	-	-	-	-	-	-	-	2,500	6,500	12,100	1,125	2,520	5,
ENTRAL														
NGOLA	2	2	-	2	-	-	25,000	35,000	16,600	28,600	48,600	7,252	13,350	26,
AMEROON	2	2	2	2	2	2	45,000	45,000	24,000	57,000	114,000	13,250	23,000	56,
EAST														
THIOPIA	2	2	2	2	2	2	90,000	90,00	60,000	166,000	330,000	30,002	83,000	160,6
ENYA	2	2	4	4	4	4	120,000	120,000	60,000	92,000	184,000	27,252	42,000	84,
ADAGASCAR	-	2	-	-	-	-	-	15,000	6,800	17,000	34,000	3,702	6,625	13,
ALAWI	2	2	2	2	-	2	35,000	45,000	38,500	46,000	92,000	18,375	21,250	42,
AURITIUS	2	2	2	2	2	2	35,000	35,000	17,400	44,000	77,000	5,302	14,750	26,
OZAMBIQUE	2	2	2	2	2	2	35,000	45,000	21,800	30,400	56,800	10,322	13,100	29,
IMBABWE	-	2	-	2	-	-	-	75,000	84,000	114,800	230,000	21,452	47,200	90,
ANZANIA	2	2	-	2	-	2	60,000	85,000	20,000	40,600	111,200	9,175	23,400	53,
AMBIA	4	4	2	2	2	2	130,000	130,000	68,800	125,800	251,000	31,752	68,050	121,5
OTAL AFRICA	46	52	30	42	34	58	1,390,000	1,865,000						
ATIN AMERICA														
ENTRAL														
OSTA RICA	2	2	2	2	2	2	50,000	85,000	60,400	94,800	173,300	33,682	35,950	60,32
L SALVADOR	2	2	2	2	2	2	90,000	90,000	69,600	106,000	180,000	35,302	50,500	86,00
UATEMALA	4	2	2	2	2	2	130,000	90,000	92,000	167,000	268,000	41,022	85,200	121,7
ONDURAS	2	2	2	-	2	-	35,000	15,000	30,300	31,600	50,600	13,322	13,350	21,37
EXICO	-	-	-	-	-	-	800,000	1,150,000						
ICARAGUA	2	2	2	2	2	2	50,000	50,000	64,200	87,000	131,000	39,822	38,500	59,50
ANAMA	2	-	2	-	2	-	50,000	-	30,600	49,600	77,020	11,022	20,000	31,25

COUNTRY	POPULATION (1000)	PER CAPUT GDP (1975 $)	PER CAPUT CEREAL PRODUCTION (KG/A)	PER CAPUT NUTRIENT CONSUMPTION (KG $N+P_2O_5+K_2O$/A)			TOTAL FERTILIZER NUTRIENT CONSUMPTION (T/A $N+P_2O_5+K_2O$)		
	1980	1980	1980	1980	1990	2000	1980	1990	2000
RICA									
ORTHWEST									
LGERIA	18,337	1,065	120	9.6	13.6	21.5	176,000	352,000	710,000
OROCCO	20,324	462	210	11.0	16.3	25.3	226,300	452,600	910,000
UNISIA	6,651	833	182	9.7	14.8	23.6	63,650	127,400	255,300
EST									
HANA	11,556	540	50	1.6	2.3	3.5	18,313	36,630	73,000
VORY COAST	5,572	908	164	6.7	10.2	15.6	37,370	74,800	149,600
IBERIA	1,937	512	125	2.3	3.7	6.5	4,550	9,350	18,620
IGERIA	87,112	341	102	1.3	1.8	2.8	113,267	226,600	453,000
ENEGAL	5,630	309	147	5.3	8.1	12.7	29,276	58,552	117,000
IERRA LEONE	3,353	216	179	0.8	1.4	2.2	2,720	6,100	10,100
ENTRAL									
NGOLA	7,101	545	56	2.0	3.1	4.6	14,358	28,716	57,432
AMEROON	7,058	432	132	4.0	6.5	10.2	29,060	58,140	116,000
AST									
THIOPIA	31,522	106	140	2.6	4.0	6.1	81,960	163,920	327,000
ENYA	15,680	256	165	2.8	4.2	5.9	46,240	92,700	185,400
ADAGASCAR	9,325	235	265	0.9	1.3	1.8	8,350	16,700	33,700
ALAWI	5,577	156	228	4.1	6.3	9.7	23,030	46,000	92,000
AURITIUS	559	715	-	27.6	40.0	48.3	26,740	53,500	106,600
OZAMBIQUE	10,375	454	46	1.7	2.0	4.3	28,500	57,000	114,000
IMBABWE	7,435	455	272	16.8	18.5	18.9	135,940	183,000	283,000
ANZANIA	18,052	188	88	1.7	2.5	3.7	30,700	61,400	122,800
AMBIA	5,875	462	154	10.8	15.3	21.7	62,300	126,000	251,600
OTAL AFRICA							1,159,424	2,238,108	4,386,052
ATIN AMERICA									
ENTRAL									
OSTA RICA	2,286	1,025	124	36.6	45.4	58.2	83,700	134,000	213,500
L SALVADOR	4,813	484	160	16.0	18.7	22.6	77,560	124,000	158,000
UATEMALA	7,100	645	170	15.1	18.3	22.4	107,900	172,600	276,400
ONDURAS	3,595	351	120	5.5	6.6	7.4	19,740	31,600	50,600
EXICO	69,965	1,375	230	16.9	19.4	23.8	1,182,500	1,932,000	3,020,000
ICARAGUA	2,733	218	135	20.0	23.1	25.5	54,900	87,900	131,700
ANAMA	1,930	1,490	137	15.7	19.2	23.5	30,400	48,700	77,000

COUNTRY	ALTERNATIVE I: SUPPLY BY INTERNAL PRODUCTION – NEW PRODUCTION PLANTS AND FACILITIES REQUIREMENT: NITROGEN FERTILIZER MINI-PLANTS		PHOSPHATE FERTILIZER MINI-PLANTS		FERTILIZER PROCESSING PLANTS & FACILITIES		ESTIMATED INVESTMENTS (US$ 1000)	
	1980-1990	1990-2000	1980-1990	1990-2000	1980-1990	1990-2000	1980-1990	1990-2000
LGERIA	4	6	6	10	6	10	210,000	330,000
OROCCO	3	10	-	-	-	10	240,600	350,000
UNISIA	2	2	-	-	4	8	80,000	100,000
HANA	2	2	2	2	1	1	30,000	30,000
VORY COAST	2	2	2	2	1	1	40,000	40,000
IBERIA								
IGERIA	4	4	4	4	8	8	200,000	200,000
ENEGAL	2	2	-	2	-	2	15,000	55,000
IERRA LEONE	-	-	-	-	-	-	-	-
NGOLA	2	2	-	2	-	-	25,000	35,000
AMEROON	2	3	2	2	2	2	45,000	45,900
THIOPIA	2	2	2	2	2	2	90,000	90,00
ENYA	2	2	4	4	4	4	120,000	120,000
ADAGASCAR	-	2	-	-	-	-	-	15,000
ALAWI	2	2	2	2	-	2	35,000	45,000
AURITIUS	2	2	2	2	2	2	35,000	35,000
OZAMBIQUE	2	2	2	2	2	2	35,000	45,000
IMBABWE	-	2	-	2	-	-	-	75,000
ANZANIA	2	2	-	2	-	2	60,000	85,000
AMBIA	4	4	2	2	2	2	130,000	130,000
OTAL AFRICA	46	52	30	42	34	50	1,390,000	1,825,000
OSTA RICA	2	2	2	2	2	2	50,000	85,000
L SALVADOR	2	2	2	2	2	2	90,000	90,000
UATEMALA	4	2	2	2	2	2	130,000	90,000
ONDURAS	2	2	2	-	2	-	35,000	15,000
EXICO	-	-	-	-	-	-	800,000	1,150,000
ICARAGUA	2	2	2	2	3	2	90,000	50,000
ANAMA	2	-	2	-	2	-	50,000	-

COUNTRY	ALTERNATIVE II: SUPPLY BY IMPORTATION – TONNAGE OF IMPORTS ($N+P_2O_5+K_2O$ T/ANNUM)			FOREIGN EXCHANGE REQUIREMENT (US$ 1000/ANNUM)		
	1980	1990	2000	1980	1990	2000
LGERIA	188,400	255,000	501,000	84,500	113,750	222,7
OROCCO	76,300	250,000	550,000	28,150	102,500	210,0
UNISIA	28,900	65,900	131,800	13,175	30,575	61,5
HANA	25,600	37,000	73,000	9,150	16,250	32,6
VORY COAST	44,000	75,000	150,000	16,150	28,250	56,5
IBERIA	4,700	9,200	18,500	2,050	4,025	8,1
IGERIA	176,700	227,000	454,000	80,000	104,750	205,5
ENEGAL	18,000	32,000	64,000	7,750	13,000	24,0
IERRA LEONE	2,500	6,500	12,100	1,125	2,500	5,0
NGOLA	16,600	28,600	48,600	7,253	13,300	26,4
AMEROON	24,000	57,000	114,000	13,250	23,000	56,0
THIOPIA	60,000	166,000	330,000	30,000	83,030	160,0
ENYA	60,000	92,000	184,000	27,750	42,000	84,0
ADAGASCAR	6,000	17,000	34,000	3,750	6,625	13,2
ALAWI	38,500	46,000	92,000	18,375	21,350	42,50
AURITIUS	17,400	44,000	77,000	5,300	14,350	26,75
OZAMBIQUE	21,000	30,400	56,000	10,300	12,100	25,2
IMBABWE	84,000	134,000	230,000	21,452	47,730	90,0
ANZANIA	20,000	48,600	111,200	9,175	23,400	51,30
AMBIA	60,000	125,000	251,000	31,752	60,850	121,50
OTAL AFRICA						
OSTA RICA	60,400	94,000	173,300	23,302	35,950	60,325
L SALVADOR	69,600	106,000	180,000	35,300	50,500	86,02
UATEMALA	92,000	167,000	260,000	41,000	85,300	131,750
ONDURAS	30,300	31,600	50,600	13,300	13,350	21,375
EXICO						
ICARAGUA	64,200	87,000	131,000	25,800	38,500	59,500
ANAMA	30,600	49,600	77,000	11,600	20,000	31,250

COUNTRY	POPULATION (1000) 1980	PER CAPUT GDP (1975 $) 1980	PER CAPUT CEREAL PRODUCTION (KG/A) 1980	PER CAPUT NUTRIENT CONSUMPTION (KG/A $N+P_2O_5+K_2O$) 1980	1990	2000	TOTAL FERTILIZER NUTRIENT CONSUMPTION (T/A $N+P_2O_5+K_2O$) 1980	1990	2000
FAR EAST									
SOUTH ASIA									
BANGLADESH	88,803	138	262	4.3	7.2	11.0	358,574	717,150	1,553,300
INDIA	684,305	158	205	7.6	9.6	12.6	5,133,036	8,321,000	13,154,000
PAKISTAN	82,551	172	205	13.1	15.31	18.55	1,089,600	1,742,900	2,388,700
SRI LANKA	15,436	262	159	10.5	14.0	19.4	162,120	259,000	414,000
EAST AND SOUTHEAST ASIA									
BURMA	35,155	157	305	3.0	5.9	6.3	109,200	210,400	349,000
CHINA	987,465	417	312	15.5	17.7	21.0	12,161,000	18,224,600	26,386,600
INDONESIA	154,865	268	208	5.8	9.3	15.1	828,466	1,757,000	3,399,000
KOREA, DPR	17,916	400	435	42.0	48.6	54.9	749,100	1,076,900	1,500,000
KOREA, REP	38,105	735	185	22.7	30.2	41.9	867,100	1,387,400	1,330,000
MALAYSIA	13,938	760	153	33.4	51.0	67.3	447,000	934,000	1,495,000
PHILIPPINES	52,183	393	202	6.9	8.3	10.2	362,100	580,000	924,000
THAILAND	49,473	394	435	6.7	9.9	15.5	331,450	462,000	1,322,000
TOTAL FAR EAST							22,254,546	35,900,340	55,344,600
ALL DEVELOPING COUNTRIES									
AFRICA							1,149,424	2,338,100	4,386,852
LATIN AMERICA							6,926,615	11,334,030	17,855,950
NEAR EAST							2,955,110	4,901,800	8,372,420
FAR EAST							22,254,544	35,900,340	55,344,600
TOTAL							33,814,691	54,515,418	86,259,052

ALTERNATIVE I: SUPPLY BY INTERNAL PRODUCTION — NEW PRODUCTION PLANTS AND FACILITIES REQUIREMENT

COUNTRY	NITROGEN FERTILIZER MINI-PLANTS 1980-1990	1990-2000	PHOSPHATE FERTILIZER MINI-PLANTS 1980-1990	1990-2000	FERTILIZER PROCESSING PLANTS & FACILITIES 1980-1990	1990-2000	ESTIMATED INVESTMENTS (US$ 1000) 1980-1990	1990-2000
FAR EAST								
SOUTH ASIA								
BANGLADESH	19	-	12	14	12	14	480,000	710,000
INDIA	-	-	-	-	44	76	3,970,000	4,230,000
PAKISTAN	20	-	20	14	30	14	1,200,000	360,000
SRI LANKA	6	4	4	2	6	4	250,000	160,000
EAST AND SOUTHEAST ASIA								
BURMA	6	6	8	4	8	6	175,000	135,000
CHINA	-	-	44	9	-	-	4,520,000	6,225,000
INDONESIA	10	-	6	10	16	10	440,000	1,520,000
KOREA, DPR	8	12	4	4	-	-	200,000	400,000
KOREA, REP	-	-	-	-	-	-	-	-
MALAYSIA	10	6	10	4	10	8	425,000	300,000
PHILIPPINES	12	8	4	6	6	6	435,000	315,000
THAILAND	14	10	14	14	14	14	630,000	510,000
TOTAL FAR EAST	96	46	130	150	146	160	12,005,000	15,965,000
ALL DEVELOPING COUNTRIES								
AFRICA	46	52	30	42	34	50	1,390,000	1,025,000
LATIN AMERICA	45	46	54	34	38	38	4,250,000	5,105,000
NEAR EAST	12	10	20	22	22	50	3,290,000	3,265,000
FAR EAST	96	46	130	150	146	160	12,005,000	15,555,000
TOTAL	152	154	232	248	236	346	21,335,000	26,100,000

ALTERNATIVE II: SUPPLY BY IMPORTATION

COUNTRY	TONNAGE OF IMPORTS (T/A $N+P_2O_5+K_2O$) 1980	1990	2000	FOREIGN EXCHANGE REQUIREMENT (US$ 1000) 1980	1990	2000
FAR EAST						
SOUTH ASIA						
BANGLADESH	277,000	603,700	1,401,300	131,500	289,130	675,700
INDIA	2,755,000	5,196,000	10,129,000	1,180,000	2,375,530	4,708,500
PAKISTAN	712,000	1,104,000	2,149,700	330,000	548,030	1,069,530
SRI LANKA	150,000	259,000	414,000	66,750	115,250	184,150
EAST AND SOUTHEAST ASIA						
BURMA	53,500	158,400	289,000	25,875	77,450	141,250
CHINA						
INDONESIA	230,000	696,000	2,330,000	112,675	301,500	1,102,500
KOREA, DPR	-	-	-	-	-	-
KOREA, REP	170,000	312,000	459,000	41,500	78,000	124,750
MALAYSIA	464,000	671,000	1,437,000	169,000	326,900	541,500
PHILIPPINES	319,500	493,000	837,000	140,100	218,500	373,500
THAILAND	318,000	625,000	1,203,000	150,750	297,750	613,000
TOTAL FAR EAST						
ALL DEVELOPING COUNTRIES						
AFRICA						
LATIN AMERICA						
NEAR EAST						
FAR EAST						
TOTAL						