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REVIEW OF THE DRAFT WORLD-WIDE STUDY OF THE FERTILIZER INDUSTRY: 1975-2000 1/

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INTRODUCTION

At the Second General Conference of UNIDO held at Lima, Peru, in March 1975, the Lima Declaration and Plan of Action on Industrial Development and Co-operation was adopted, and subsequently endorsed by the General Assembly at its seventh special session. In the Declaration, the role of industry was re-asserted as a dynamic instrument of growth essential to the rapid economic and social development of the developing countries, and a target was set whereby the developing countries' share of world industrial production should be increased from its present level of 7 per cent to at least 25 per cent by the year 2000.

Among the mandates entrusted to UNIDO in the Lima Declaration and Plan of Action was the recommendation that "in order to give concrete content to the process of industrialization in the developing countries, studies must be undertaken and specific measures formulated in different sectors of industry, special attention being given to priority sectors". The fertilizer industry, which is one of the largest manufacturing industries in the world, was selected as a subject for one of the first world-wide studies in view of its vital importance to agricultural production and industrial development in many developing countries. Further reasons for studying this sector were the need for increased food for growing populations and the abundant supply in many developing countries of raw materials for fertilizer manufacture. Various comparisons have been made between the amount of increased food production attributable to fertilizer use and that attributable to more effective irrigation, the improvement of plant varieties and the control of weeds, pests and diseases as well as other improved agricultural practices. Such comparisons, however, are akin to estimating how much a single cog in a machine contributes to the machine's output.

The purpose of the study is to identify the main opportunities for the advancement of the fertiliser industry and to assess the potential contribution this sector could make to the attainment of the over-all industrial production target set in the Lima Declaration. It has been prepared in the light of experience in this sector. Inevitably, the study and its projections, as well as the methodology used to obtain such projections, will be revised periodically in the light of changing circumstances.

The review contained in this document comprises two parts: a summary of the draft study, and considerations for future action. The draft study will be reviewed at a technical meeting in November 1976, whereafter a final version will be distributed.

SUMMARY

Fertiliser consumption to the year 2000

In the study, fertilizer consumption has been projected for the period 1980-2000. The method used was a simple mathematical projection of past trends using linear regression equations of the form $\sqrt{F} = A + BT$. The study also presents projections of fertilizer consumption in principal regions of the world as well as in 40 individual countries in Africa, Asia and Latin America.

Figure I shows trends in fertiliser nutrient consumption from 1955 to 1974 with projections to the year 2000, at which time world consumption will be 307 million tons as compared with 83.6 million tons in 1974 - a 3.7-fold increase. Assuming an average nutrient content of 42 per cent ($N+P_2O_5+K_2O$), the gross weight of fertiliser consumed per annum would be 731 million tons by the year 2000. Nutrient consumption in developing countries is expected to increase from 19.3 million tons in 1974 to 110 million tons in 2000 - a 5.7-fold increase.

The above projections are based on historical patterns of fertilizer consumption, not on estimates of food requirements: estimates based strictly on the nutritional requirements of increasing populations would probably be higher for most developing countries and lower for many developed countries. Any forecast is subject to increasing uncertainties as the forecast period is extended, hence no great accuracy can be claimed for the present projections. They do, however, serve to indicate the potential for expansion in the fertilizer industry up to the end of the century.

The table on page 5 shows the past and future consumption for the individual nutrients in both developed and developing countries.

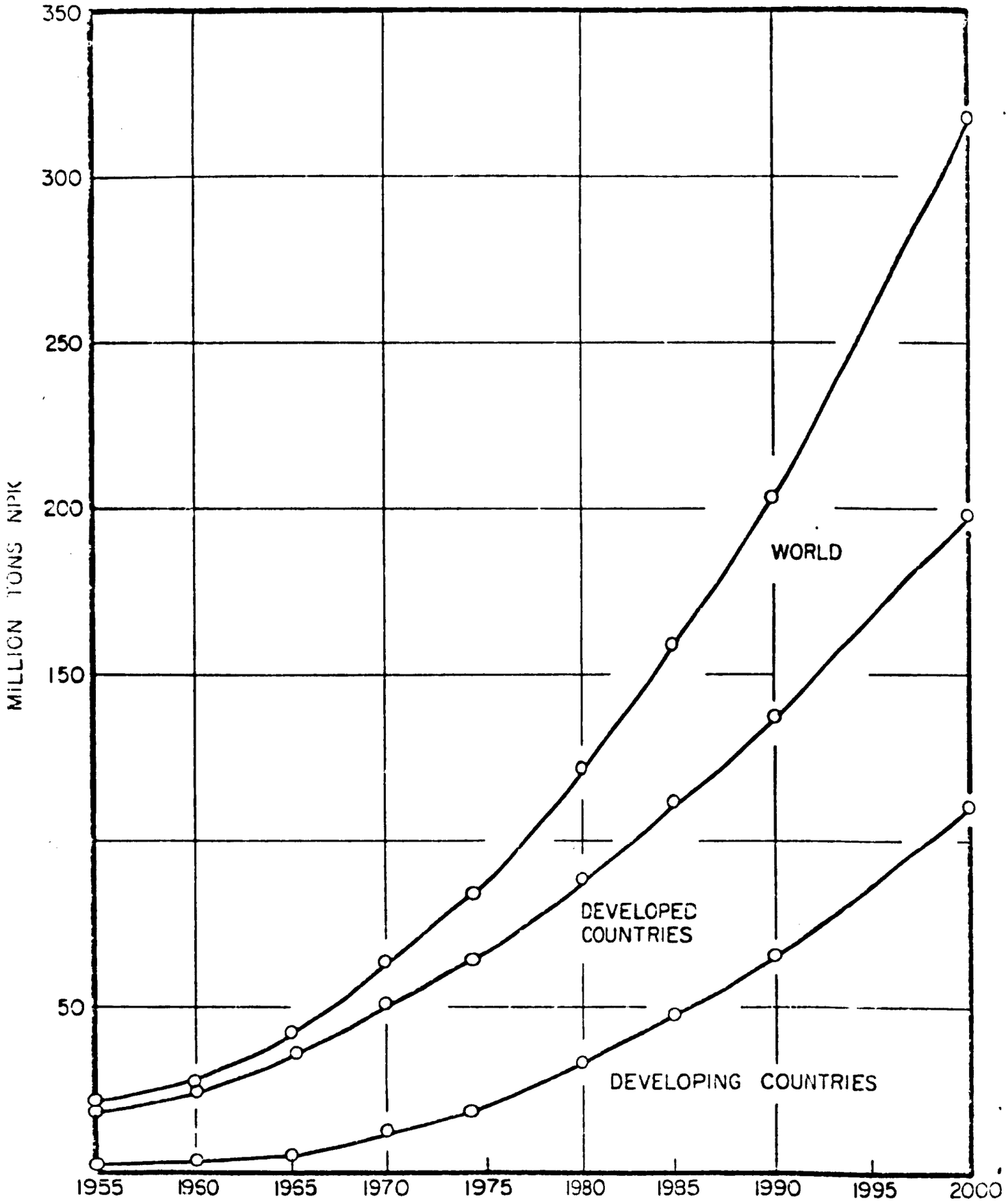

Figure I. WORLD FERTILIZER CONSUMPTION

Year	Developed countries				Developing countries			
	N	P_2O_5	K_2O	NPK	N	P_2O_5	K_2O	NPK
	(millions of tons)							
1974	27.3	18.9	18.1	64.3	11.4	5.3	2.6	19.3
1985	53.0	29.0	29.0	111.0	28.0	13.0	7.0	48.0
2000	101.0	46.0	50.0	197.0	64.0	30.0	16.0	110.0

The table shows that developing countries as a whole are expected to maintain a nutrient ratio $N:P_2O_5:K_2O$ of approximately 4:2:1 throughout the 1974-2000 period, whereas the developed countries are expected to increase the nitrogen component from a ratio of 1.4:1.0:1.0 in 1974 to 2.2:1.0:1.1 in 2000. Thus the greater part of the growth will be in nitrogen fertilizers in both groups. The world-wide nutrient ratios should not be assumed to imply an optimum ratio for any individual country; country ratios should and do vary widely according to the needs of their soils and crops.

Fertilizer production

Fertilizer production in developing countries has always lagged behind actual consumption; in 1974, it was only 64 per cent of consumption. As a result, developing countries as a group are net importers of fertilizers; in 1974 net imports amounted to 7.7 million tons (nutrient basis). This situation, combined with rapidly increasing needs, would seem to provide developing countries with strong incentive to establish and expand fertilizer production facilities. Many developing countries have an abundance of the raw materials needed for nitrogen and phosphate fertilizer manufacture. In this connexion, it should be noted, however, that potash production was not considered since, strictly speaking, it is a mining and beneficiation industry, and very few developing countries have commercially exploitable reserves of potash.

The report presents two alternative plans for world fertilizer production, in which different assumptions are made about the location of the new plants needed between 1980 and 2000. In Alternative A, it is assumed that developing countries as a group would become self-sufficient in the production of nitrogen and fertilizers by the year 2000. To achieve this aim, 40 per cent of world nitrogen and phosphate fertilizer production

would take place in these countries. In Alternative B, it is assumed that 50 per cent of world production of those nutrients would take place in the developing countries. Since the developing countries themselves consume only 40 per cent of world production, the latter alternative implies that they would export 20 per cent of this production to developed countries. Neither alternative assumes that each developing country in the group would become a self-sufficient fertilizer producer. It is presumed that factories will be mainly located where economically viable combinations of raw materials and markets (local and foreign) exist.

The production of nitrogen fertilizer is highly capital-intensive. The estimated capital cost of constructing the number of nitrogen and phosphate fertilizer plants required during the period 1980-2000 is summarized below:

	Developing countries	Developed countries	Total
	($ billion)		
Alternative A	53	61	114
Alternative B	75	44	119

The difference between the two alternatives reflects the higher capital cost and lower utilization of plants in developing countries. The estimates are based on 1975 prices and make no allowance for interest charges during plant construction or for the cost of connecting the factory to road and rail systems, and to water and power supplies. These items, which were excluded because they vary so much from one project to another, would, on an average, increase the costs given above by about 20 per cent.

Additional capital expenditure would be required for mining and refining raw materials, for transporting and distributing the products and for creating the appropriate physical and technical infrastructure. It is not possible to make a comparable estimate of this additional capital owing to the wide variations in the location and quality of raw material deposits and in the methods of product transport and distribution. However, it is unlikely that it will be less than the manufacturing capital, and it could be appreciably greater.

At this juncture, it should also be pointed out that the manner in which the capital needed to develop the fertilizer industry is to be obtained will be influenced by decisions reached on the allocation of productive capacities, including the location of plants. These factors will have a decisive bearing upon the magnitude of financial assistance. These endeavours to identify an appropriate system of international financing notwithstanding, large-scale investment in the fertilizer industry is being effected at present in a variety of forms. However, it should be emphasized that both the magnitude and form of financial assistance to the development of the fertilizer industry have to be seen in the context of the over-all financial requirements of development in both the agricultural and industrial sectors. In the light of the above, further in-depth study will have to be undertaken at the appropriate time.

For the purposes of estimating the capital requirements, it was assumed that the new plants would produce:

Ammonia
Urea
Diammonium (DAP)
Triple Superphosphate (TSP)
Compound or complex fertilizers based on the above materials with potash added as potassium chloride

While in certain cases other products might be more useful or economic, their effect on the total capital required would be negligible. It was assumed that all nitrogen fertilizers would be ammonia derivatives, with only a small percentage (mainly ammonium sulphate) emanating as by-products from other industries. All new ammonia plants were assumed to have a rated capacity of 1,000 tons per day. Whereas larger or smaller plants might be economically preferable in specific situations, the effect on total capital requirements would be comparatively small.

It is estimated that natural gas will be the feedstock used in the majority of new ammonia plants (72 per cent in 1980-85 and 64 per cent in 1990-2000). Naphtha will be used in some 5 per cent of new plants, and heavy fuel oil in about 15 per cent. Coal will find application in 9 per cent in 1980-85 increasing to 17 per cent in 1990-2000. The choice of feedstock greatly affects the capital cost of ammonia plants; at present coal-based plants cost nearly twice as much as those based on natural gas.

It was assumed that in developed countries the amount of anhydrous ammonia used directly as fertilizer would decrease from 15 to 10 per cent and in developing countries it would increase from 2 to 8 per cent. Ammonium sulphate and the nitrogen content of ammonium phosphate would supply about 10 per cent of total nitrogen fertilizer. The remainder was assumed to be urea or ammonium nitrate either straight or in compound fertilizers.[1/] The cost calculations are based on urea, but ammonium nitrate costs would not differ significantly. Underutilization of rated capacity sharply increases production costs: the present average utilization is estimated at about 60 per cent in developing countries. For the purposes of the report, however, it is assumed that all plants established after 1980 would on an average operate at 90 per cent of their rated capacity 3 to 4 years after start-up.

All new phosphate plants were assumed to have a daily capacity of at least 600 tons of P_2O_5. Smaller or larger plants may be economically preferable in many cases. It was assumed that the plants established after 1980 would produce DAP (80 per cent) and TSP (20 per cent). Though other products might be more appropriate in certain cases, their effect on over-all worldwide costs would not be significant. It is recognized that there will always be a place for single superphosphate and other low-analysis products that have local agronomic application or that lend themselves to the exploitation of local resources. The capital requirement for the production of some of these processes is comparatively low, but the cost of transporting low-analysis products is higher per unit of plant nutrient. Since it is not a manufactured product, ground phosphate rock was not considered in this study. However, if its direct application becomes widespread, the need for chemically manufactured phosphates will decrease.

The demand for compound fertilizers will increase in most countries; by the year 2000 it is expected that 65 and 86 per cent of P_2O_5 will be in this form in the developing and developed countries, respectively. The cost of producing compound fertilizers was not taken into account except where it represented a minor addition to the cost of granulating DAP. The preparation of compound fertilizers by mixing, bulk blending, or granulation in local plants was considered part of the distribution and marketing system.

[1/] The term "compound fertilizers" is used here to include all fertilizers containing more than one of the major nutrients, N, P_2O_5, and K_2O.

Raw materials

It is unlikely that development of the fertilizer industry from 1980-2000 will be seriously hampered by shortages of raw materials. Phosphate rock, potash, coal, and, in the long term, sulphur are abundant. Natural gas and, especially, crude petroleum are less plentiful. However, if past experience is any guide, further reserves will be discovered in due course. It is estimated that in 1980, the demand for ammonia feedstock will constitute only 3.5 per cent of total gas production and less than 1 per cent of total oil and coal production. This notwithstanding, these premium raw materials can be expected to rise in price, thus leading to a significant shift in some countries to coal as a raw material for ammonia towards the end of the century.

It is difficult to assess the changes which may occur in the supply of sulphur owing to the variety of forms in which it is produced and to the fact that at present the major reserves in coal and gypsum are not economically competitive. Moreover, an increased use of natural gas and petroleum products coupled with improvement in environmental standards will lead to greater elemental sulphur recovery, and to greater recovery of sulphur dioxide produced in fuel combustion or smelting operations. For most of the period under review, elemental sulphur will continue to be the major raw material source, but it is possible that by the end of the period there will be a swing towards other sources.

Reserves of potash are ample, but most of them are located in the developed countries. Therefore, pending the discovery and exploitation of deposits in the developing countries, most of the developing countries will have to import their potash requirements.

Phosphate rock is widely, albeit unevenly, distributed among developed and developing countries, and serious shortages are not anticipated. Indeed, in recent years, the rate of discovery has far exceeded that of consumption. However, given the continuance of the present trend towards lower rock grades, producers and consumers may well have to exercise greater sophistication in their evaluation, specification, grading, and selection of this material.

Water is consumed in large quantities in the manufacture of fertilizers, of N fertilizers in particular. Consumption can be reduced through appropriate plant design, but it will always be large. An adequate supply of water is therefore an important, and maybe decisive, factor in the location of fertilizer plants.

Organic fertilizer materials

Organic materials and chemical fertilizers play complementary roles. Chemical fertilizers stimulate the production of organic materials, and the return of waste organic materials supplements chemical fertilizers. The total amount of organic wastes is very large, and their nutrient content is thus impressive; in 1971, the estimated NPK content of organic wastes in the developing countries was seven times that of chemical fertilizers. Many of these "waste" materials are already being used as fertilizers or for fuel and other purposes. However, those that are not being used involve technical, economic, or social problems owing to their bulk, low concentration of nutrient elements, or to the presence of potentially harmful ingredients.

Organic materials, such as crop residues, help to improve soil texture and moisture-retention capacity. With the increased use of chemical fertilizers and the resultant increased crop yields, more crop residues are available for ploughing back into the soil.

More efficient use of organic wastes is desirable. In this connexion, numerous studies are being undertaken, aimed at the recovery of fertilizer and/or energy values, and at the disposal of pollutants. Despite the value of these studies, the amounts of additional fertilizer thus recovered are unlikely to contribute significantly to meeting future fertilizer needs.

Marketing

The objectives of marketing fertilizers are to ensure that the right fertilizer is at the right place at the right time, and to demonstrate to the farmer the benefits to be derived from its use.

In addition to factory storage facilities, regional and village storage centres are essential to ensure prompt distribution in sufficient quantity. Estimates must be made of fertilizer requirements in each area in order that the local centres are adequately stocked in advance. Costs should be

minimized through appropriate utilization of available transportation facilities, including waterways. Existing transportation networks will need to be improved and extended in order to cope with the increased flow of fertilizer to the farmers and that of agricultural produce to the markets. Mixing facilities might be provided at regional or district distribution centres in order to ensure the supply of fertilizers appropriate to the regions and their crops. These facilities may range from simple mixing and bulk blending to granulation processes, with the possibility of adding secondary or micronutrients as required.

The capital requirements for marketing may be of a magnitude comparable to those of manufacture. These capital requirements would include the cost of transportation as well as the erection of regional distribution centres to be equipped with bulk blending or granulation, bagging and storage facilities. The requirements also include district distribution centres and working capital to cover the cost of material in storage and loans.

In any study of the fertilizer industry, particular consideration must be given to the socio-economic aspects of fertilizer use and the way in which any constraints these impose can be overcome. Investment in fertilizer production is to no avail as long as the farmer remains unconvinced of the desirability and profitability of its use. Reluctance to use fertilizers might be minimized in several ways: by lowering fertilizer cost; by increasing fertilizer effectiveness; or by obviating socio-cultural inhibitions.

Fertilizer costs should be reduced in the first instance by maximizing the efficiency of the manufacturing and marketing systems. Fertilizer effectiveness may be raised through development of improved fertilizer materials, improved placement and timing of application, more effective water control and plant protection, as well as improvement of plant varieties. Extensive effort will have to be made to convince the farmer of the need for increased and more effective use of fertilizers, while the return that he obtains for his produce can be increased by improving the marketing and processing systems.

Even when farmers have been convinced of the profits to be gained from increased fertilizer use, some form of credit will have to be made available to permit them to buy it. Further encouragement might take the form of

fertilizer, credit or crop subsidies, and tax concessions. As comparatively few countries dispose of the resources needed to become entirely self-sufficient, production and marketing on a regional basis may well prove mutually beneficial.

Location of fertilizer plants

The main principles governing plant location as a means of minimizing capital requirements as well as operating and distribution costs are outlined. One of the principal objectives is to minimize the cost of fertilizer delivered to the farmer. Other considerations, which may affect plant location, include national security or self-sufficiency, foreign exchange savings, and assistance to less developed regions; their possible effect on fertilizer cost and, in turn, on food production, should be taken into consideration.

Planning and production within a regional context would permit a more efficient utilization of the individual countries' resources: be they natural gas for ammonia production in one country, sulphur or sulphuric acid in another, phosphate rock in a third, or even potash in a fourth. Regional plant locations are cited and the substantial savings in capital and operating costs to be derived therefrom are briefly examined. Another regional solution might lie in an arrangement whereby a number of countries develop at least enough indigenous production to meet a percentage of their needs, while relying on imports from their regional partners for the remainder. In this way, complementarity in raw material use, fertilizer production and trade within a region would be enhanced.

Environmental considerations

Fertilizer plants can cause pollution because many of the materials they process or produce are harmful to animal and plant life or may adversely affect the quality of the environment. Damage may occur through the gaseous or liquid effluents which are continually discharged, through occasional accidental leakage or through major accidents.

The prevention of leakage or major accidents depends largely on satisfactory equipment design, but it is primarily a matter of technically qualified and alert plant management with particular and painstaking attention

to regular and reliable maintenance.

With regard to the control of effluents, stringent environmental standards are mandatory in most developed countries. However modern fertilizer plants are usually designed to meet these standards under the most unfavourable operating conditions. In normal operation, therefore, effluent quality is better than that legally enforced. The additional capital cost involved in attaining those standards is normally about 10 per cent of the total, and the capital costs cited in the report include this extra capital.

Manpower

The projected development of the fertilizer industry will require increased numbers of engineers, scientists, management personnel, marketing experts, maintenance and operating personnel, and other workers. The estimated total number of additional workers required for the two alternatives discussed earlier is shown below for the period 1980-2000:

	Alternative A	Alternative B
Developing countries	209,000	298,000

The above estimate includes only those workers directly and exclusively concerned with production and distribution. It does not include workers in such areas as mining, beneficiation, and transport of raw materials, nor does it include persons engaged in the sale of fertilizers along with other farm supplies in such ancillary industries as bag production, fertilizer application machinery, equipment manufacture, and construction. In all probability, at least one million workers will need some sort of training in fertilizer production or handling, not to speak of the hundreds of millions of farmers using the fertilisers. Manpower and training requirements will affect investment inputs and the attainment of commonly agreed production goals.

In view of the urgent training needs of the developing countries, details are given of training programmes that have been established in several developing countries. Organization charts of typical training establishments are also shown.

Policies for fertilizer industry development

The successful expansion of the fertilizer industry in developing countries at the rate visualized in either Alternative A or B is clearly contingent upon relevant policies at the national and regional levels. In this respect, the study suggests specific areas in which decision-makers should elaborate policies on fertilizer production and distribution.

The study discusses the implications of government policies with regard to raw materials. Special reference is made to exploration programmes, as well as to research and development programmes directed towards defining optimum use of resources. Attention is also drawn to the importance of pricing policies and price setting. Other raw material policies described relate to the utilization of indigenous raw materials as well as to that of by-products. Policies related to fertilizer production cover the planning of new facilities for maximum efficiency and economy, as well as the need to match production targets with user requirements.

With regard to marketing, transportation and distribution facilities for fertilizer products, the critical relationship between food production and fertilizer inputs may necessitate special policy measures. Policies which have a bearing on marketing infrastructure, on the pattern of fertilizer allocation as well as on research and extension services will have to be co-ordinated in the course of the sector's development.

Emphasis is also placed on policies aimed at increased fertilizer use. In this connexion, the study examines the possibility of employing direct or indirect subsidies, agricultural price support systems and measures to increase agronomic response.

Human resource management will play a substantial role in the development of the fertilizer industry. The study briefly examines the development and acquisition of necessary skills as essential components of national development programmes in the fertilizer industry.

New investment mechanisms and forms will be required to ensure that the necessary capital is available to meet projected outlays. The utilization of capital should be in conformity with national and regional objectives and compatible with their corresponding needs.

CONSIDERATIONS FOR FUTURE ACTION

As emphasized at the outset, the study constitutes a first attempt by UNIDO to assess the fertilizer industry sector on a global scale up to the year 2000. The central theme of the study is that both national and regional policies must be related to projected fertilizer demand and production. Furthermore, the study points up a number of topics which have to be discussed and investigated further. These topics are summarized below:

(a) In developing the projection methodology applied in this study, a basic constraint was the limited time available to complete the work. Therefore, a model was devised relating consumption to time as the only independent variable on the assumption that the past fertilizer/time relationship will continue in the future.

In forming alternative scenarios of future growth, further study would be needed to make allowance for the effects that the actual growth of fertilizer demand and supply will have on this relationship, including changing economic conditions, improved crop varieties, the development of crops with reduced fertilizer requirement, more effective techniques of fertilizer utilization as well as other scientific and technological developments. Scenarios could also take into account fertilizer consumption projections based on such factors as food requirements, raw material constraints and fertilizer requirements of non-food crops.

(b) Within the framework of the two fertilizer production alternatives presented, as well as of any other alternatives based on future forecasting models, the distribution of production capacity and the location of industry will have to be studied further with a view to identifying alternative solutions to be discussed and acted upon by the parties concerned.

(c) In order to ensure achievement of the production level required for the world as a whole, studies should be made of the development of a monitoring system for production and trade, as well as of a system of guarantees for meeting agreed production targets.

(d) A comparative study should be made of existing fertilizer production policies at the national and regional level with a view to identifying alternative policies for production rationalization and its integration with agricultural development policies as well as with policies governing the industrial and mining sectors, the outputs of which are needed to attain fertilizer production targets.

(e) The relevant experience and knowledge acquired hitherto by many developing countries could be effectively applied to the development of fertilizer production in other developing countries. To the extent that the experience and capabilities thus acquired are considered applicable, policies will have to be studied and elaborated with a view to facilitating and strengthening co-operation among developing countries in such areas as investment, technology, engineering and construction, training and joint production schemes. Specific attention should be devoted to developing and promoting the most effective means of exchanging information among developing countries as well as measures to monitor fertilizer production.

(f) Furthermore, the advantages and implications of promoting foreign private investment in this sector should be examined further. If, within the framework of overall economic priorities, preferential treatment for foreign investors is justified, the limits, incentives and guarantees to be offered should be elaborated.

(g) Further research should also be carried out into pricing structures and policies and their implications for prices paid by fertilizer users, the development of the fertilizer industry, the creation of an investment climate, and trade.

(h) The fertilizer technology market is highly competitive: the problems that occur in the developing countries are not so much related to the acquisition of know-how as to its more effective utilization. This latter problem should be closely studied, particularly in relation to local requirements and policy objectives. Study is also required of the nature and scope of fertilizer development policies in which the availability of investment capital is not necessarily tied to the acquisition of licences or know-how.

(i) Further research is also needed into the causes underlying the present low levels of capacity utilization in developing countries, as a step towards enhancing the level of production and ensuring that production targets are met by existing and new capacities.

(j) Trends in feedstock use and the resultant utilization of appropriate technologies have been estimated only roughly. Since technological changes will affect capital expenditure as it relates to production targets, developments in fertilizer-related technologies need to be continuously monitored and more accurately forecast.

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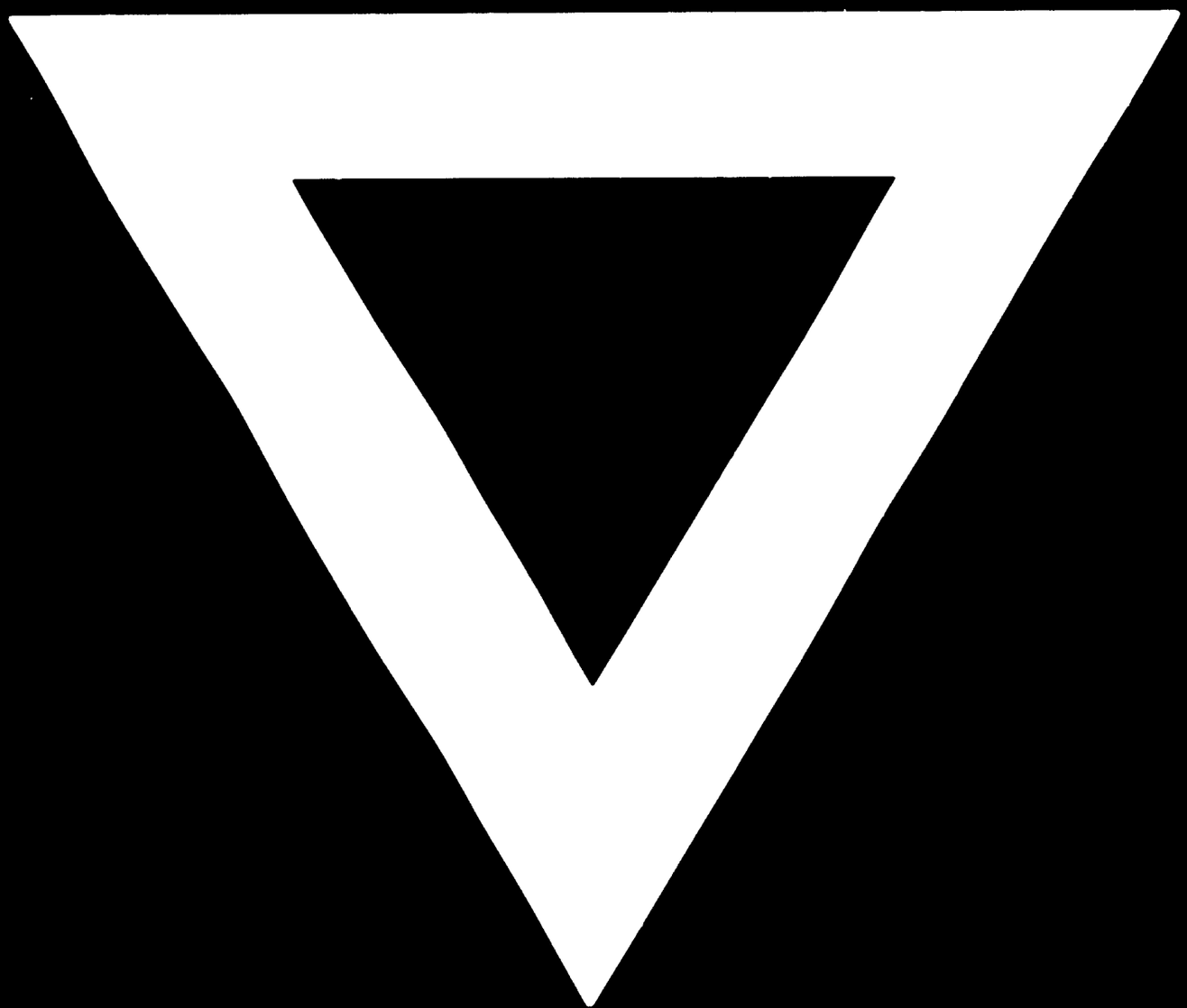

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