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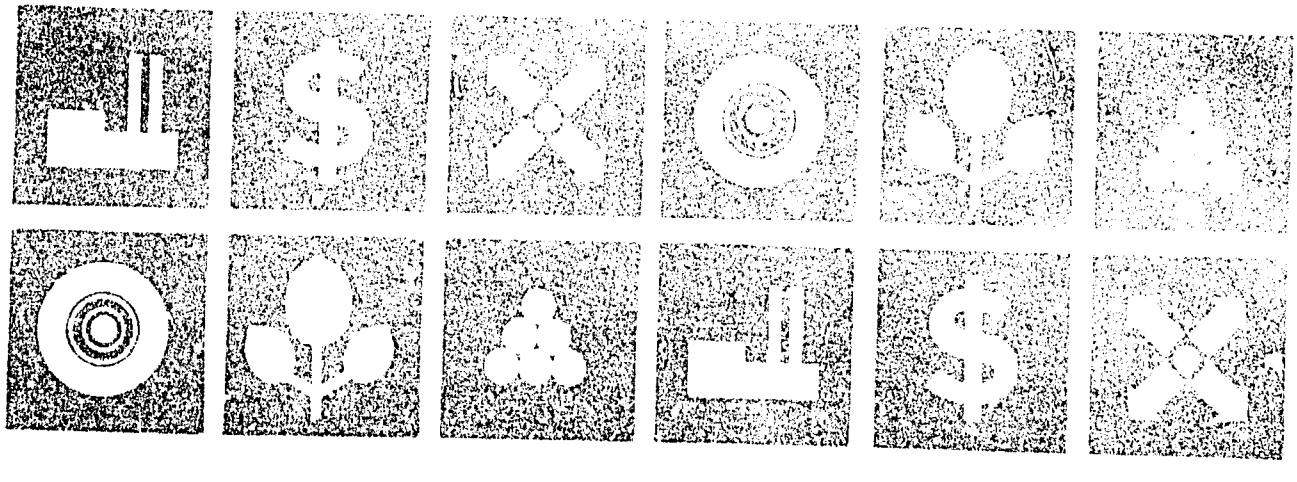
INTERNATIONAL FERTILIZER DEVELOPMENT CENTER

Suggested Fertilizer–Related Policies

For Governments & International Agencies



FOREWORD

The present report is issued by the International Fertilizer Development Center (IFDC) in the hope that it will be helpful in assisting governments and international agencies in formulating policies that will facilitate long-range planning of fertilizer production, distribution, and use, particularly in developing countries.

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TABLE OF CONTENTS

Summary 1

Introduction 4

Part I—Policies of Individual Governments 5

Raw Materials 7
Fertilizer Production 13
Marketing, Transportation, and Distribution 18
Measures to Increase Fertilizer Use 26
Manpower Utilization and Training 35
Investment and Financing 37

Part II—The Role of International Organizations 43

Introduction 43
Research and Development 44
Technical Assistance and Training 56
Improved Data Collection, Processing, Reporting, and Forecasting on World Fertilizer Investment, Production, and Use 58
Loans and Grants From International Agencies 61

References 65

SUMMARY

In order to build a sound agricultural base for industrial development, developing countries should increase their production, distribution, and use of fertilizer to provide adequate food supplies for their growing populations. A goal of increasing fertilizer use in the developing countries by at least five-fold by the year 2000 seems reasonable. Also, developing countries as a group might well set a goal of collectively approaching self-sufficiency in fertilizer manufacture by the year 2000. Attainment of the goal would help achieve the aspirations of the developing countries to increase industrial production. Some policies that governments should adopt to attain these goals are:

1. Stimulation of exploration to discover and to define the extent and quality of resources of raw materials needed for fertilizer manufacture. Such stimulation may be promoted by policies that attract investment capital through joint ventures, leases, concessions, or other agreements based on equitable sharing of products or profits, or alternatively by national exploration programs.

2. Performance of research and development including economic studies to determine the best use of resources to meet the present and long-term future needs of the countries. Conservation and environmental aspects should not be neglected.

3. Fertilizer production and distribution systems should be planned for maximum efficiency and economy using a level of technology commensurate with the needs and abilities of the countries. Investment capital and expertise can be attracted through joint ventures when appropriate. Policies aimed at increasing utilization of fertilizer production capacity and reducing production costs should be emphasized.

4. Stimulation of fertilizer use should emphasize decreasing cost through more efficient production and distribution and increasing the efficiency of fertilizer use through agro-economic research and farmer education. Direct or indirect subsidies should be used only after considering alternatives.

5. Utilization and development of human resources should be given due consideration in selection of level of technology, in training programs, and in personnel policies that reward efficiency and achievement.

6. Tax incentives and streamlining procedures for obtaining foreign materials, supplies, spare parts, and services will help attract investment capital and promote efficient operation. Fragmentation of responsibility should be avoided as far as possible, and close coordination of all concerned organizations at the working level should be emphasized. Particular emphasis should be placed on coordinating infrastructure development and agricultural programs with fertilizer production and/or distribution.

7. Possibilities for integrating fertilizer manufacture with other industries should be sought and consummated when advantageous.

International organizations should adopt or continue policies to carry out research and development in areas that will be of general benefit to developing countries. Priority should be given to increasing the quantity and efficiency of fertilizer use through:

1. Promotional activities to demonstrate the value of fertilizers for increasing crop production, and to assist in market development.

2. Development and use of improved forms or compositions of fertilizer materials, especially those that may be more effective in tropical or subtropical agriculture.

3. Improvement of placement and timing of application and proper balance of nutrients.

4. Other improved practices (water control, plant protection, etc.).

5. Development of new varieties that utilize fertilizer more efficiently or supply part of their requirement through symbiotic nitrogen fixation.

International organizations should also assist through research and development on utilization of difficult ores of types that occur in several developing countries. This activity may include improvements in mining and beneficiation techniques,

selection or adaptation of processes, or development of new processes.

Identification or development and adoption of low-technology processes would be very helpful to many countries in early stages of development. Such processes should employ small, simple, inexpensive plants, often with liberal use of labor.

Studies of more efficient utilization of organic waste materials should concentrate on methods that recover energy as well as fertilizer values. Increased contribution of these materials to fertilizer supplies is expected to be relatively minor.

International organizations should gather, evaluate, and disseminate information on technology and economics of manufacture, distribution, and use of fertilizers; this information should include the results of research and development outlined above.

International financial agencies should support new facilities when investment capital cannot otherwise be obtained. They should support projects aimed at transfer of new technology, including low technology when appropriate.

Appropriate international organizations should improve the collection, evaluation, and dissemination of data relating to fertilizer consumption, demand, and supplies, including correlation with food production and raw material supplies. They should use this information to make more accurate and timely forecasts of needs to promote orderly development of the industry.

SUGGESTED FERTILIZER-RELATED POLICIES FOR GOVERNMENTS AND INTERNATIONAL AGENCIES

INTRODUCTION

It is generally agreed that developing countries as a group should plan to increase their use of fertilizer by at least five-fold during the remainder of the century (1976-2000), primarily to help provide an adequate food supply for the growing population. It has also been proposed that the developing countries should adopt a minimum goal of increasing fertilizer production rapidly enough to collectively approach self-sufficiency on or before the year 2000. This goal will involve production of about 110 million tons of NPK in the year 2000, as compared with 13.5 million tons in 1975.[1,2] This proposal is in line with the developing countries' desire of increasing their share of the world's industrial production.

It should be noted that a goal of "self-sufficiency" in fertilizer production for developing countries is not intended to imply each country will be self-sufficient, nor does it imply absence of trade between developed and developing countries. Self-sufficiency is intended to mean that developing countries as a group produce as much fertilizer as they consume, and they export to developed countries at least as much fertilizer as they import from them.

It is evident that achieving these goals will require that a high priority be assigned to increasing fertilizer production, distribution, and use with maximum efficiency. The purpose of this report is to suggest some policies that may be employed to pursue such goals. Some of these policies may already be in effect and may need only increased emphasis. Others may involve some significant changes in policy for some countries.

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1. NPK = N + P_2O_5 + K_2O; tons = metric tons.
2. Years used in this report refer to the split year ending on June 30 of the year specified.

PART I—POLICIES OF INDIVIDUAL GOVERNMENTS

Individual countries exercise varying degrees of control over the fertilizer industry and agriculture ranging from moderate control of private enterprise to complete control of fertilizer production, distribution, and use. In suggesting government policies, it is evident that not all of the suggestions will apply equally to all types of governments. Nothing in this report should be construed to imply a preference for one form of government over another; this is a political matter that each country must decide for itself.

It is often easier and sometimes more enlightening to propose an activity or a desired result than the policy by which it is promoted. This is especially true because of the wide variety of politico-economic systems involved when speaking of a large group of countries such as "developing nations." Therefore this chapter often suggests activities that may be influenced by governments without defining the policy which promotes the activity.

Suggested policies of individual countries will be discussed under six sections.

Raw Materials
Fertilizer Production
Fertilizer Marketing and Distribution
Measures to Increase Fertilizer Use
Manpower Utilization and Training
Investment and Financing

These subjects are not necessarily in the order of suggested priorities. In fact, the order of priority is likely to vary widely from one country to another. For some countries discovery and development of the mineral resources needed for fertilizer production may receive first priority, particularly when the alternative of importing raw materials or finished fertilizers would be very expensive. Other countries that already have known abundant resources may assign a low priority to this activity.

Countries where foreign exchange is limited may assign a high priority to financing, while those with an excess of foreign exchange may be little concerned with this problem.

It is suggested that most developing countries should place a very high priority on establishing a sound, productive, efficient agriculture, which will serve as a foundation for industrial growth. Many countries do not have adequate food supplies, even though the majority of the people are engaged in agriculture. Establishing an efficient fertilizer production and/or distribution system is only one of several requirements for productive agriculture, but it is usually an essential one. As this report deals mainly with fertilizer it does not pretend to cover completely all of the policy actions required for improving the agricultural sector.

Another high priority need in most countries is improvement of the infrastructure. This need is related to fertilizer manufacture and use in several ways, as pointed out under "Marketing and Distribution" and some other sections of this report. The need for infrastructure improvement is not solely related to fertilizer production and distribution, but it is essential to the successful operation of the fertilizer sector and to agriculture in general, and too often it is a limiting factor.

Among those needs that relate more specifically to fertilizers, maximizing capacity utilization, investment policies, realistic consumption targets, and more effective fertilizer use often deserve high priority. More effective fertilizer use often involves a better balance of nutrients, better placement or timing of application, and many other factors. These factors need to be identified by agricultural research and promoted by farmer education.

Countries that have little agricultural potential but abundant raw materials for fertilizer production may view development of a fertilizer industry primarily as a means of earning foreign exchange. Their highest priorities are likely to be efficiency of operation and marketing so that their products can compete profitably in the export market.

Raw Materials

Exploration Programs

Most countries strive to become as self-sufficient as possible by making maximum use of their own resources. However, in many countries there has been only minimal exploration to discover and define mineral resources. Even the most developed countries frequently have incomplete information. It is recommended, therefore, that each developing country should develop policies that would lead to the intensification of efforts to discover and define the quality and quantity of its resources as related to fertilizer production. Such policies relate to (a) type of resource needed; (b) ownership of mineral resources; and (c) responsibility for development (government, private, or joint venture).

Fertilizer-related resources will include natural gas, petroleum, coal, oil shale, oil sands, hydroelectric and hydrothermal energy sources, phosphate rock, sulfur minerals, and potash minerals. Other resources that may prove useful are liming materials (calcite, dolomite, wollastonite) and micronutrient elements. Sodium minerals (natron or trona) may be useful in Rhenania-type processes; magnesium silicate minerals (olivine or serpentine) may be used in production of fused calcium-magnesium phosphate. In some cases mineral resources may have dual uses; for instance, metal sulfide ores, such as copper sulfide can supply sulfuric acid for fertilizer as well as valuable metals.

Ownership of mineral deposits or mineral rights vary widely and have an important effect on incentives for exploration and development. In some countries, all mineral rights are owned by the federal, state, or provincial government. In other countries, the landowner also owns the mineral rights. In some cases, the discoverer of a mineral deposit on government land may be granted ownership, subject to requirements that the deposit be developed. In some cases, ownership policies are more complex and may depend on the type of mineral or its importance to national interests. In the case of undersea deposits, there may be international complications.

When the government owns the mineral rights, public policies relating to exploration, development, and utilization are especially important. In some countries, it is government policy to conduct exploration and to develop, mine, and utilize the mineral resources, either through government-owned corporations, or directly as a function of government. Government subsidized

institutions may be formed for exploration or for utilization research. In such cases governments must decide what minerals or raw materials should be sought and, when found, which ones should be developed and utilized. However, many developing countries do not have the funds or competence to carry out major programs of exploration, development, and utilization research.

One method of attracting investment capital and technical competence is through a system of leases, concessions, or joint ventures. The terms of the agreement may involve royalties or sharing of production or of profits, or other arrangements. Obviously, the potential profit should be sufficient to attract investment capital but the agreement should protect both the national interests and the investor. This is a common arrangement for exploration and development of petroleum and natural gas deposits. Similar arrangements may be applied to other fertilizer raw materials.

Examples of attracting foreign capital for exploration and development of natural resources based on a production sharing agreement are found mainly in the petroleum and natural gas industry. Indonesia and Malaysia are among several countries that have worked out mutually satisfactory arrangements with foreign organizations.

For those countries that prefer to rely on their own resources for exploration and development of mineral deposits, the example of China may be considered. In Chinese policy of "development from within," industrial development policy starts with available mineral resources. Exploration to identify such resources is emphasized.

The New China News Agency on December 23, 1974, described geological exploration:

> "Hundreds of geological teams composed of tens of thousands of geologists and hundreds of thousands of workers and staff members are now engaged in regional geological surveys, searches and prospecting of mineral ores, petrogeology and hydrogeology, engineering geology and geophysical prospecting. . .New China has set up a dozen or more geological institutes and schools and geological departments at a dozen universities. The number of worker-peasant-soldier students enrolled in geology this year is the biggest since the beginning of the cultural revolution. . .China attaches great importance to mobilizing the masses, the peasants in particular, to report ore deposits and outcroppings. . .Many big deposits were found by the masses and verified

by geologists. . .Many counties, people's communes and brigades have set up groups to collect leads on underground minerals. People look for mineral deposits while they build water-control projects, railways, roads and farmland improvement projects and plant trees. During slack farming seasons, people are organized to search for minerals in the mountains. The geologists often go to the villages to spread knowledge of how to identify various ores. . . New China has set up a dozen large factories manufacturing such equipment and instruments. Many medium-sized and small ones have also been set up. The Chinese geological force is being equipped with modern means for prospecting from the air, the sea, the land surface and underground. The geological departments have over 400 times as many drilling machines as in the early post-liberation years."

Research and Development Program to Define Optimum Use of Resources

Often mineral resources are not of standard quality, and considerable research may be needed to find ways to use them efficiently in fertilizer production. This is particularly true of phosphate rock; each phosphate deposit has its own peculiarities and often requires extensive study to determine how or whether it can be used economically. Many other minerals pose unusual problems. This activity is one that requires a high degree of technical competence and ingenuity. Developing countries may well need technical assistance. The research should not seek solely to find ways to beneficiate the mineral to meet the requirements of standard processes; adapting the process or selection of nonstandard processes should also be considered. In many cases it may be more economical not to beneficiate relatively low-grade ore when the fertilizer product is mainly for domestic use. For instance, TSP containing 40-44% P_2O_5 made from unbeneficiated ore is likely to be just as good as a 46-48% P_2O_5 grade and much cheaper when an expensive beneficiation step can be avoided.

Pricing Policy

Indigenous raw materials for fertilizer manufacture are often subject to price control based on government policy. This is especially true of ammonia feedstocks that have alternate uses, such as energy sources, or petrochemical feedstocks. Export is another alternate use when the mineral is of standard quality. Sulfuric acid has many alternate uses other than fertilizer manufacture.

Pricing of indigenous raw materials to fertilizer manufacture is a complex subject. Following are some of the possible bases for pricing:

1. The price may be based on the value for alternate uses (e.g., ammonia feedstocks may be based on value for fuel for electricity generation). When there is no alternate use for associated natural gas, the price may be equated to the cost of collection, purification, and transportation to the plant site. Byproduct sulfuric acid from smelter operations must be recovered to prevent atmospheric pollution; in some cases, the only alternative to using it for fertilizer manufacture is an expensive disposal method, such as neutralization with limestone to form calcium sulfate which is discarded. In such cases, the price of the acid to fertilizer manufacture may be zero or even negative.

2. The price may be based on the export or import price of the same material, or near substitute.

3. The price may be based on cost of production.

4. Other bases may range from pricing for maximum profit to a subsidy to permit competition with imports.

It is not within the scope of this report to recommend a general pricing policy. Perhaps it is sufficient to suggest that governments should consider the effect of raw materials prices on fertilizer production cost and adopt appropriate policies to achieve overall development goals.

Utilization of Indigenous Raw Materials

When indigenous raw materials are unusually expensive or of poor quality, it is often governmental policy to use them even when they are not competitive with imported materials. This policy may be justified by savings in foreign exchange, increased employment, and safeguards against foreign manipulation of supply or price. It is suggested, however, that the policy be flexible enough to avoid unreasonable costs or limitations on fertilizer supply. Alternatives should be considered such as regional self-sufficiency or bilateral trade agreements.

When the indigenous raw materials supply is limited, the government may allocate available supplies among alternate uses. Natural gas is one example. Since natural gas is worth much more as ammonia feedstock than as an energy source, it may be appropriate in many cases to give priority to use for ammonia

production. On the other hand, when sulfur or sulfuric acid is in short supply, governments may find it expedient in some cases to select fertilizer processes that avoid or minimize its use.

Conservation of resources should be an important part of government policy. Minerals utilization policies should be tied to long-term needs for the raw materials and to the most advantageous uses. Practices such as flaring of natural gas or "high-grading" of ore deposits for quick, short-term exploitation should be discouraged as far as practical. When the low-grade ore must be removed to mine high-grade ore, it may be appropriate to require stockpiling the low-grade ore for future use when conditions or technology warrant.

Import and Export Policies

Many countries will need to import some of their requirements for fertilizer raw materials. Government policy will affect importation through decisions on import duties, preferential trade agreements, etc. Likewise, when one or more raw materials are abundant, government policy may regulate exports. Also, government policy may encourage exportation of finished or intermediate products rather than raw materials to take advantage of value added by processing. Even more value may be added by domestic use of fertilizers to provide agricultural products for export.

Regional cooperation in utilization of fertilizer raw materials may often be advantageous and is strongly recommended in regions where raw materials of good quality and quantity are scattered among several countries, or where the fertilizer requirement of individual countries is not large enough to justify an economical scale of production.

Utilization of Byproducts of Other Industries as Raw Materials for Fertilizer

Very often byproducts or coproducts from other industries can be used as raw materials for fertilizer production. Examples are:

Sulfur recovered from sour gas, oil, or coal
Sulfur or sulfuric acid from smelting sulfide ores of zinc, lead, copper, or nickel
Apatite from beneficiation of iron ore
Basic slag or ammonium salts from steel industry

Coke oven gas, refinery tail gas, or LPG for ammonia feedstock
Ammonium sulfate from caprolactum production
Ammonium chloride from soda ash production

Government policy can enter into utilization of these byproducts in several ways. For instance, the government may require that sulfide ores be smelted in the country in order to recover sulfuric acid for fertilizer production rather than to export the ore for smelting in another country. If necessary, it may subsidize one industry such as copper smelting to ensure development of a phosphate industry. It is evident that government planning and coordination can be helpful in insuring optimum use of byproducts, and integration of other industries with fertilizer industries.

Examples of integration of fertilizer production with other industries in developing countries include:

1. In Brazil, beneficiation of low-grade phosphate ore yields a high-grade phosphate concentrate, and limestone which is utilized for cement production.

2. In Iran, sulfur recovered from natural gas is used as a basis for a phosphate fertilizer industry.

3. In Colombia, ammonium sulfate solution, a byproduct from caprolactum, is utilized in a nitrophosphate fertilizer process.

4. In the Philippines, plans for smelting copper concentrates in the country (rather than exporting them) are being implemented. The byproduct sulfuric acid will be used for fertilizer production. A similar plan is under consideration in Indonesia.

In summary, suggested government policies related to exploration, development, and utilization of fertilizer raw materials are:

1. Exploration for fertilizer raw materials should be expanded. Investment capital and technical expertise can be attracted by joint ventures, concessions, or other agreements that offer the investor an adequate incentive but provide for the countries' needs and protect its interests. Sharing of production is one arrangement. Government ownership and leasing policies should encourage such arrangements.

2. Utilization of unusual or nonstandard raw materials may require extensive research and development. When the prospects are not sufficient to attract investment capital, developing countries may well seek assistance from international agencies or donor nations.

3. Government policy should consider long-term needs and best alternative uses of raw materials. Suggested policies include conservation to avoid wasteful use for short-term advantage, integration of other industries with fertilizer production, regulation of exports, and regional cooperation.

4. Pricing of raw materials or feedstocks to fertilizer industries should take into account the effect on fertilizer costs and resulting effects on farmer use and food production.

Fertilizer Production

Planning New Facilities for Maximum Efficiency and Economy

The first decision in planning a fertilizer industry is whether a new plant should be built, and, if so, what kind. Realistic estimates of present and future market demand or requirements are needed as a basis for this decision. If the intention is to export part of the production, an analysis of world or regional supply and demand is needed to determine to what countries the product could be sold competitively, and what the market is likely to be in those countries. In considering exports it would be well to initiate some inquiries, perhaps at government levels, to determine the plans and policies of prospective importing countries. Such data are needed to establish that importation is likely to be acceptable to the importing country. Some sort of a trade agreement might be mutually beneficial.

When fertilizer production is planned for domestic use only, the type of facilities may depend on the estimated market. General guidelines, to which there may be many exceptions, follow. If the market is less than 5,000 tons per year of fertilizer, it is unlikely that any facilities can be justified other than those required to receive and distribute bagged fertilizers. For market volume between 5,000 and 25,000 tons per year, facilities for receiving bulk fertilizers for bagging may be considered. Also in this range, a small bulk-blending plant could be considered if special formulations are needed that cannot be imported except at a much higher price than the ingredient materials.

Between 25,000 and 100,000 tons per year, bulk-blending or granulation may be considered. In the case of a granulation plant, imported intermediates such as phosphoric acid, powdered monoammonium phosphate, ammonia or ammoniating solutions, potash salts, and urea may be used; and local production of superphosphate may be considered if either sulfuric acid or phosphate rock (or both) are available.

In the range of 100,000 to 300,000 tons per year, basic manufacture of some types of fertilizers may be considered if the raw material situation is favorable. However, manufacture of urea usually is not considered economical unless the scale of operation is 300,000 tons per year or more. Above 300,000 tons per year basic production of ammonia, urea, and phosphoric acid may be considered, but the mere fact that prospective demand is sufficient to utilize the production of a full-scale plant is no guarantee that the project will be economically justifiable. For instance, if a country has neither phosphate rock nor sulfuric acid, it may not be economical to manufacture phosphoric acid unless there is assurance of an economical supply of these materials. Likewise, when a country has no economical indigenous supply of ammonia feedstock, basic production of ammonia and nitrogen fertilizers may be uneconomical in comparison with importation. On the other hand, for inland countries where importation is very expensive and when raw materials are available, relatively small plants often can be economically justified.

For these reasons each project must be considered separately; there are likely to be many exceptions to the general guidelines given above.

When production is planned mainly for the domestic market, the planning should be closely integrated with the plans and goals of the agricultural sector. Reliable, realistic estimates of future needs become extremely important. If this demand is overestimated, the plant will be too large, and the production cost will be high due to underutilization of capacity. If the estimated demand will support an economical scale of production in the more distant future (10-20 years), it may be better to include construction of a plant in long-term rather than short-term planning.

Another important decision is the type of ownership of fertilizer production and distribution systems. This subject will be discussed in the next section, to avoid repetition.

The type of products to be made is another important decision. Government policy should relate agricultural needs with those products that are most likely to be produced efficiently and economically by industry. Sometimes this decision may involve some compromise between agronomic, economic, and technical factors. For instance, NP products (ammonium phosphates or nitrophosphates) are often more economical to produce than straight materials. Ammonium phosphates, because of their high concentration, are more economical to transport, and because of their physical properties they are more adaptable to bulk blending than single or triple superphosphate. These advantages should be weighed against any disadvantages. Another example: use of ground phosphate rock for direct application may be economically preferable in some cases to the more expensive water-soluble phosphates. Flexibility should be provided to permit changes in types and quantities of products as future conditions warrant.

Plant location analysis is important. Government policy may affect plant location in several ways. For instance, the extent of regional cooperation or trade agreements will affect the market area and source of raw materials and hence plant location. Also, the government may wish to locate the plant in an area of high unemployment for social or political reasons, or in market areas to minimize transportation problems. Government plans for improving transportation systems, waterways, and port facilities should be taken into account.

When raw materials are to be imported, it is generally poor policy to build a facility dependent on a single source. For instance, in planning a phosphoric acid plant, it is well to build in enough flexibility to use phosphate rock from a variety of sources.

Selection of process and of plant design and construction firms should place due emphasis on reliability and experience of the contractor. Political considerations should be minimized.

Maximizing Capacity Utilization and Minimizing Production Costs

Capacity utilization of fertilizer production facilities averaged only about 60% in developing countries in 1974, even in countries where fertilizers were in short supply and imports were required to make up the deficit. Such low capacity utilization has a disastrous effect on production costs. However, there are several cases in which plants in developing countries have

operated for extended periods (several years) at or above rated capacity as demonstrated in Korea, Indonesia, and Pakistan.

Although the immediate causes of poor production records are numerous, many of them are traceable to government policies or deficiencies in government planning. Conversely, the good records seem to result from high priority set by the government on fertilizer production, together with incentives, authority, and responsibility placed on the operating organization to take necessary steps to insure efficient performance.

Some illustrations of causes of poor plant performance are: defects in plant design or construction; poor choice of product or process; lack of a timely supply of raw materials; deficiency in raw material quality; lack of skill, experience, and managerial or technical competence; delays in obtaining suitable spare parts; and electric power interruptions or failure of water supply.

Lack of incentive to maximize production may result when the government controls the price at a level equal to or below the cost of production. When the government controls the price of fertilizer products at cost of production plus a percentage, there is an incentive to maximize production, but not to minimize cost. On the contrary, the tendency may be to increase costs (such as by overstaffing) in order to increase profits.

Poor coordination between production, distribution, and agricultural needs may cause low capacity utilization. Inadequate transportation facilities for distribution of products may contribute to this problem.

Suggested government policies to maximize efficiency of fertilizer production are:

1. Formulate procedures for selection of engineering and construction firms to attract the most reliable and competent ones.

2. Centralize responsibility for plant operation, giving plant management maximum freedom to make decisions.

3. Streamline procedures for procuring imported raw materials, spare parts, catalysts, supplies, and services of foreign experts, liberalizing the use of foreign exchange for these purposes.

4. Ensure a timely supply of indigenous raw materials and services and maintain quality standards of feedstocks and

supplies. Preferably procurement of all necessary raw materials, supplies, and services, both imported and domestic, should be under the control of the plant manager.

5. Provide incentives for efficient operation to both management and employees.

6. Provide training programs.

7. Encourage sound preventive maintenance programs.

8. Maintain close coordination between production, transportation, and marketing, including imports or exports. In many cases production and marketing by the same organization may result in the most effective coordination.

9. When necessary, provide subsidies, tax concessions, or import duty exemptions (discussed later).

Some developing countries may object to some of the above policies that involve liberalizing use of foreign exchange. However, these policies should result in a net decrease in foreign exchange requirements due to decreasing the need for importation of fertilizer or food, or increased export income when fertilizers are produced for export.

Pollution Control

Each country should establish some standards regarding the environmental aspects of mining and beneficiation of raw materials and manufacture of fertilizers. In some cases, pollution control has been ignored with unfortunate results. In other cases, unnecessarily stringent regulations have been adopted. It is suggested that governments should set standards designed to:

1. Protect the health of workers in the plant and of the people in the community by avoiding harmful concentrations of known pollutants in the atmosphere in and surrounding the plants.

2. Avoid damage to crops and other vegetation.

3. Prevent deterioration of the quality of water in streams, lakes, estuaries, or harbors; and protect other industries and people who use the water.

4. Maintain aesthetic values that are essential to pleasant surroundings, and to attraction of tourists.

Marketing, Transportation, and Distribution

The marketing, transportation, and distribution of fertilizers is fully as important as production. The capital requirement of the distribution system may equal or approach that of the manufacturing facilities. This includes the cost of transportation facilities; regional and district marketing centers equipped with facilities for storage, bagging, and (sometimes) bulk blending; and working capital to cover the cost of material in storage and credit costs. A significant portion of the farmer's cost of fertilizer may be related to distribution costs; sometimes even exceeding 50%. Obviously the distribution system should receive as much attention as the production system in government planning. In fact, the two systems are so dependent on each other that any shortcomings in one will adversely affect the other.

The object of the distribution and marketing system is to ensure that the required amount of the right kind of fertilizer is on hand at the right time and place, and to convince the farmer that he should buy and use it. All of these functions are critical.

Realistic Estimates of Demand

The importance of realistic estimates of demand on planning efficient production facilities has already been mentioned. It is equally important in planning an efficient marketing system. For this purpose, demand estimates need to be detailed by region and district, by time requirements (weekly, monthly, seasonal), and by type of fertilizer. Governments in developing countries should encourage their fertilizer industries to obtain the specialized information that is needed for planning market programs. Such governments also should encourage independent projections of demand by both patriate and nonpatriate organizations and should require, at the least, one of its own ministries to prepare or procure both short-range and long-range demand projections. Realistic demand estimates are so essential to both fertilizer production and marketing and government economic planning that poor estimates should not be tolerated; until government is confident that it can produce reliable estimates, relying on outside expertise for assistance may be preferred.

Development of Infrastructure

When plans are made for expanding the production and use of fertilizers, one of the [illegible]t bottlenecks in many countries is

that of transportation. Movement each year of a few hundred tons of imported fertilizer from a dock is no problem at all compared to moving a thousand tons per day from a modern fertilizer plant. Even this daily movement is not a full indication of the transportation problem. Each ton of plant nutrients can be expected to increase grain production by 5 to 10 tons. Presumably most of this increased production will need to move out of the production area and into the commodity marketing channels. Food problems cannot be resolved, then, unless increased production of fertilizer is accompanied by a major improvement in transportation facilities. Similar improvements are needed in other aspects of infrastructure: electricity, communications, storage silos and warehouses, markets, etc. Again the policy implications are clear: there must be a balanced development of infrastructure, fertilizer production, and effective distribution of the additional food supplies.

Coordination With Government Agronomic Research and Extension Service

As mentioned elsewhere, each government should conduct an adequate program of agronomic research in order to generate information that will enable its farmers to use fertilizer with maximum efficiency and profitability. Such information should include identification of the most effective balance of nutrients and the most effective timing and placement of application. Recommendations should take due account of economic factors, and should provide some latitude in choosing alternatives to provide for variations in prices of various types of fertilizer or variations in supply.

The fertilizer marketing personnel should keep fully informed of the latest agronomic information and should be prepared to supply fertilizers called for by government recommendations. In fact, an alert marketing organization takes on many of the functions of an extension service and supplements it by establishing local demonstration plots and keeping farmers informed about best practices.

Government Allocation of Fertilizer

In case the demand exceeds the supply, the government may allocate fertilizer in accordance with various criteria as follows:

1. When the country's food supply is critically short, the government may allocate a major portion of the fertilizer supply to food crops. Among food crops, it may favor those

crops or varieties that respond most to fertilizer, or it may favor crops that the people mainly depend on for their food supply, or it may favor crops that provide the best balance of nutrients for the most people.

2. The government allocation may favor crops that have the most favorable effect on foreign exchange. The favored crops might be food crops in some cases, or they might be high-value export crops.

3. Allocation may aim to achieve a fair distribution among provinces or districts, or among individual farmers, such as providing a percentage of estimated needs or of the previous year's use.

4. The allocation may favor the poorer or smaller farmers.

There also can be a need for allocation even when supply exceeds demand. This situation arises when price ratios are not favorable for the use of fertilizer on certain crops deemed essential to the national economy (such as food crops). Regardless of these price ratios, governments can step in and require--as a matter of policy--the use of prescribed quantities of fertilizer on the essential crops before fertilizer can be used on nonessential crops. Somewhat similarly, governments can require that fertilizer be supplied to certain areas or regions, or to certain classes of farmers, regardless of the profitability of this particular market. Policies such as these must be clearly described so that fertilizer marketing groups can develop appropriate marketing plans.

Any system of allocation has drawbacks. Frequently, allocations involve some type of subsidy and/or a controlled price or selective subsidies may be used instead of allocations as discussed later. The alternative of a free market will result in price increases which will reduce the demand to match the supply. This may result in the major portion of the fertilizer going to more prosperous farmers or high value export crops. The policy implications are these: the government must give very careful study to the effects allocation will have on food production and income distribution before implementing such a policy.

Ownership of Production and Distribution Systems

Government policies are likely to depend on the extent of government ownership of production and distribution systems; production and marketing are so interdependent that the two are considered together in this discussion.

Types of ownership of production and/or distribution systems are:

1. Wholly owned by government and operated by government.

2. Wholly owned by government and operated as an independent corporation.

3. Partially owned by government and operated as an independent corporation; other shareholders may be private companies (foreign or domestic). The government may have either a majority or minority interest.

4. Wholly owned by private corporations or individuals.

There are also countries where government-owned corporations coexist with privately-owned ones, sometimes in competition with each other.

While it is often the case that the same corporation operates both the production and distribution systems, separate ownership also frequently occurs. In either case, a close coordination between production and distribution is necessary, and some government action may be necessary to ensure it. Normally, ownership of both systems by the same organization should facilitate coordination and cooperation, but this is not necessarily so. For instance, when responsibility is divided between several government ministries (industry, transportation, and agriculture, for example), there can be as much difficulty in coordination as when the systems are separately owned. In any case, the government should take appropriate steps to resolve these difficulties.

In case of separate ownership, either the production or distribution system may be wholly or partially government-owned and the other system may be privately owned. Instances can be found where each system works well. In some cases, mixed government and private ownership of production and distribution systems have evolved due to lack of government policy. It might be desirable for the government to formulate a clear, well-considered policy regarding the extent of government ownership at an early stage in the development of the industry.

Types of Distribution Systems

A distribution system usually consists of two, three, or more tiers with the fertilizer producer at one end and the farmer at the other. While the simplest system would seem to be direct sale

from the producer to the farmer, this is seldom practical except for farmers in the immediate vicinity of the fertilizer factory.

In one system described by the World Bank Consultative Group on Food Production and Investment in Developing Countries, the distribution system is divided into regional marketing centers, each equipped to distribute about 35,000 tons of fertilizer per year through 80 retailers, each with 1,200 farmer customers.[3] The regional center will have storage facilities, soil testing facilities, and agricultural advisors; it may have bulk-blending or granulation facilities to prepare compound fertilizers. The retailers provide additional storage and are responsible for transport from the regional center. The regional centers may be operated by the fertilizer manufacturing organization, or they may be operated by a separate organization.

In other systems fertilizer marketing and distribution may be integrated with crop collection, processing, and marketing. In this case two or more distribution systems may be needed, such as one for cash crops for export and one for farmers producing food crops for domestic consumption. The number of marketing organizations also requires some consideration. There are advantages and disadvantages in permitting several organizations to market fertilizers, which will vary from one country to another.

The advantages and disadvantages of cooperative marketing are generally well known. Nevertheless, it has been difficult to attain the advantages when cooperatives have been organized in developing countries. Almost always the difficulties have stemmed from the cooperative having been organized by the government and run according to government needs and concerns. In the few cases where farmers themselves have formed cooperatives, experiences have been more favorable. Such cooperatives often prove to be efficient and provide fertilizers to their members at minimum cost. Such cooperatives have been conscious of their member needs but have not always been successful in obtaining the kinds of fertilizers and services needed.

One principle that should not be overlooked is that the effectiveness of fertilizer use is primarily dependent on the farmer, and the farmer most often turns to his local retailer for advice. Therefore, the government should take necessary steps to ensure that retailers are properly informed about how to give or procure useful information for their farmer customers.

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3. Document F, December 2, 1975, ref. FPI/76/1-7.

Marketing Compound Fertilizers

In the early stages of development, most of the fertilizer used in developing countries is in the form of straight (single nutrient) fertilizers, particularly straight nitrogen products. As the market matures, the need for compound fertilizers is expected to increase. There is often a need for a variety of fertilizer products; different soils and crops may require different NPK ratios, and often one or more of the secondary elements or micronutrients may be needed. Often large plants do not have the flexibility to produce a variety of products. Also, the basic manufacturing facilities may be at widely separated locations; a nitrogen plant may be located near a source of natural gas, a phosphate plant may be located near a phosphate rock deposit or near a source of byproduct sulfuric acid, and potash may enter the country at ports. Assembling these materials at a single location for redistribution as compounds may involve unnecessary transportation costs. The best solution to this problem will vary from one country to another. One system that has several advantages involves further processing of basic products by mixing, bulk blending, or granulation. Mixing and bulk blending usually are considered to be part of the marketing system, whereas granulation is part of the production system.

One alternative to marketing through a mixed fertilizer industry is to combine production and mixing. This approach is used in South Korea where phosphate and nitrogen plants are adjacent. Three low-nitrogen grades of varying PK ratios are produced in granular form and these grades are blended (physically mixed) with prilled urea to make additional NPK grades which are bagged for distribution. This system works well when it is economically feasible to locate nitrogen and phosphate production plants in the same or adjacent locations. Another possibility is mixing or blending locally.

It is beyond the scope of this chapter to discuss all of the alternative arrangements for producing and marketing compound fertilizers. It should be sufficient to suggest that governments should select a system that has the capability and flexibility to produce and market to the farmer an adequate variety of compound fertilizers to meet both present and likely future needs at minimum cost.

Growth in Marketing Services

Depreciation and obsolescence are recognized characteristics of production plants. Management foresees these problems and continually plans to circumvent them. Marketing systems also can

become obsolescent unless management maintains a vigorous program of innovation. It may be desirable for government to recognize this need when it establishes operating guidelines for fertilizer marketing firms. It should be within the purview of government policy to encourage management personnel in a marketing organization to attend management shortcourses and international fertilizer conferences on a regular basis. Government policy can also require orientation courses for new employees and annual or more frequent informational seminars for all employees.

Management, preferably on its own initiative but at the requirement of government if necessary, should annually budget a part of its income for testing new marketing ideas and services.

At the same time that a marketing organization plans a positive program to prevent obsolescence, government itself must plan and budget a similar program. The infrastructure upon which fertilizer marketing depends deteriorates with time or becomes inadequate for increased needs unless there is a positive program for its maintenance and improvement. Roads and highways wear out as do also rail wagons and electric power generators. Government must plan for the orderly replacement and expansion of these items and prepare its budget accordingly.

Quality Control Regulations

It is a function of government to set up and enforce regulations relating to the quality of fertilizers. The purpose of such laws and regulations is to protect the farmers by ensuring that they get what they pay for and to protect the legitimate manufacturers and merchants from unscrupulous ones.

Enforcement of fertilizer regulations usually involves a system of inspection by government inspectors. Inspection may take place at the manufacturing facility, in distribution channels, or at the farm. Obviously, the closer to the farm the inspection, the less the opportunity for adulteration. The inspection may consist of checking the weight and taking samples for chemical analysis and determination of physical properties. Usually a prescribed "tolerance" is allowed for deviation from guaranteed analysis which allows for errors in analyses and minor errors in manufacturing, mixing, or sampling.

Deficiencies in weight or analysis are penalized by a system of fines and/or payment of damages. The manufacturer, mixer, or distributor also may be penalized by revocation of his license for repeated violations. Criminal penalties may be given when there is clear evidence of intent to defraud.

Government regulations should not be so restrictive as to impose unnecessary hardship (or expense) on the manufacturer, or to prevent farmers from taking advantage of low-cost materials. For instance, a regulation that only water-soluble P_2O_5 can be claimed in a phosphate fertilizer is unnecessarily restrictive and seldom, if ever, can be justified by agronomic data. A similar situation applies to water-insoluble nitrogen derived from either natural or synthetic sources. Such materials often are sold at a premium price because of their slow-release quality which makes them more effective fertilizers in some situations. However, the nitrogen in some organic compounds is so slowly soluble as to be nearly worthless as a fertilizer. Fraudulent or misleading claims for soil-improving materials, growth stimulators, hormones, etc., should be discouraged by government regulations.

In summary, government regulation of fertilizer quality should protect farmers and honest merchants against fraudulent practices and inferior products and provide necessary information about the quantity and quality of the nutrient content of fertilizers. It should be flexible enough to permit the sale of low-cost materials or byproducts while providing adequate information about their value.

Examples of Marketing Systems

Following are two examples of marketing systems that are quite different but both successful:

Mexico's experience in achieving large gains in fertilizer production and consumption over the past decade should be of interest to many developing countries because they share many points of similarity: limited land resources; tropical climate; need for irrigation expansion and improvement; active land reform programs; strong public sector involvement in fertilizer programs; etc. Also, Mexican farming methods range from the highly sophisticated and commercial to the subsistence and traditional types. The country has the capacity to satisfy a major portion of its fertilizer needs through domestic production. By government decree, fertilizer distribution is the responsibility of a single government organization, Guanos y Fertilizantes de Mexico, S.A. (GUANOMEX). However, small amounts of fertilizer are distributed through accredited distributors, subdistributors, agents, and agricultural associations and banks. Although GUANOMEX has a virtual monopoly on fertilizer distribution, there is quasi-competition among wholesale distributors within the states. GUANOMEX distributors have been carefully selected on the basis of management capability, financial position, community position, and willingness to distribute fertilizers. Fertilizer pricing policy

is the responsibility of CUANOMEX. Fertilizers are sold under a price equilization principle in which prices at the main distributor level are uniform. Prices at the farm level may vary from state to state. Fertilizers are not subsidized (1).

The Japanese fertilizer marketing system has two major distribution channels: agricultural cooperatives and private merchants. The system is largely dominated by the cooperative organization, accounting for about 88-90% of the retail fertilizer market in recent years. The marketing system is unique in that distribution is entirely free of government controls and has been since August 1950. The government no longer participates in price fixing but does provide guidance and supervision in the annual price negotiations between the cooperatives and the manufacturers' association. There are no government subsidies on fertilizer. There are minor variations in fertilizer prices throughout the year but there is no apparent concerted effort to promote sales during off-seasons. The practice of ordering fertilizer in advance has streamlined fertilizer production and distribution processes, but it does not allow for unexpected changes in farmer fertilization plans. In this respect the private firms are better able to meet immediate needs of the farmer. Credit for fertilizer purchases is highly developed through the cooperative organizations but much less so for the private merchants. The cooperatives also have a highly organized technical guidance service of several years standing. The private sector was forced to develop a similar guidance service (2).

Measures to Increase Fertilizer Use

Fertilizer use is determined primarily by fertilizer and agricultural product prices, the response to fertilizer, and the presence or absence of constraints to fertilizer use such as lack of knowledge, risk and uncertainty, lack of credit, and limited fertilizer availability.

Fertilizer use can be influenced by a variety of government policy measures. The purpose of this section is to discuss some such measures. No attempts will be made to suggest which measures should be applied in a particular case. The choice of the appropriate policy for a certain country and at a given time period would depend on the particular set of circumstances and the associated costs and expected benefits from alternative measures. General guidelines will be provided, however, regarding the pros and cons of various measures. Such guidelines are primarily based

on experiences from countries where the particular policies have been applied.

Successful government policy aimed at expanding fertilizer use must either provide the farmer with an economic incentive to expand fertilizer use or remove or reduce the effect of existing constraints to obtaining potential economic benefits from expanding fertilizer use.[4]

Economic incentives may be provided through a reduction of fertilizer prices, an increase in agricultural product prices, or an increase in the agronomic response to fertilizer through better balance of nutrients, better timing or placement of application, and other inputs (water supply, improved varieties, etc.) Policy measures aimed at each of these three goals are discussed in the following. Then follows a discussion of government policy aimed at removing constraints (other than price) to expanded fertilizer use.

Reducing Fertilizer Prices to the Farmer

Lower fertilizer prices would normally increase fertilizer use unless the presence of certain constraints (discussed later) prohibits such increase. The relationship between price change and the corresponding change in the quantity demanded is measured by the price elasticity of demand. This term expresses the percentage change in quantity demanded caused by 1% change in the price. The magnitude of this term is extremely important to estimate the impact of price policies on fertilizer use. Although elasticity estimates are subject to varying degrees of error, it appears that, for each one percent decrease in the fertilizer price in many developing countries, the quantity demanded would tend to increase by 0.5 to 1.0% in the short run, and by 1 to 2% in the long run. Additional economic analysis is needed to obtain more accurate estimates of the price elasticity of demand for particular countries and regions in order to improve estimations of the impact of price policies.

Government policies aimed at increasing the efficiency of fertilizer production and marketing make possible a decrease in fertilizer prices at the farm level and, in turn, an increase in fertilizer use and agricultural production. Alternatively, foreign trade policies aimed at the protection of domestic

4. This statement applies in countries where the farmer is free to decide for himself. In some countries, fertilizer use may be centrally planned, or decided by tribal council.

fertilizer mining and manufacturing may increase the farm level price and, in turn, reduce fertilizer use. Such policies were discussed previously and this section will focus on direct government intervention in the farm level price.

Direct Price Subsidies--Direct price subsidies for fertilizer are very common in developing countries. Dalrymple lists 20 African, 12 Asian, and 3 Latin American countries that had direct subsidies in the 1960's and early 1970's (4). The number has increased since the fertilizer price rise. Some developed countries (Great Britain and Australia for example) have used direct subsidies. Subsidies may be paid directly to the farmer, to the distribution outlets, or to the fertilizer manufacturers. If sufficient control is maintained to assure that they are in fact being reflected in the fertilizer price to the farmer, direct subsidies may be a very effective means to expand fertilizer use. However, if the subsidy is of sufficient size to have a significant impact on use, subsidy programs tend to be very expensive. Furthermore, unless policies are introduced to expand fertilizer supplies simultaneously with the subsidies, the latter will promote fertilizer scarcities and the potential increase in use due to the price subsidy will only be partially realized.

Subsidies may be successfully used to introduce fertilizer on farms with favorable crop response but where no fertilizer is currently being used. As will be discussed later, the decision to use fertilizer for the first time may be greatly influenced by lack of knowledge and corresponding risk and uncertainty. To overcome such constraints, the fertilizer price may have to be lower for the first purchase than for subsequent ones.

Temporary subsidy programs may also be effective to rapidly expand fertilizer consumption in countries with excess productive capacity and resulting high domestic prices. As consumption increases, capacity utilization goes up and per unit costs may be reduced. This, in turn, would reduce the need for a continuation of the subsidy program. The problem with such temporary subsidies is that, once introduced, they tend to be difficult to phase out.

An FAO Fertilizer Industry Advisory Committee (FAO/FIAC) ad hoc Working Party on the Economics of Fertilizer Use initiated a series of country case studies on fertilizer subsidies in 1974. A review of direct subsidies in 21 developing countries was completed in 1976. Alternate sources of funds for direct studies, program administration, and a strategy for phasing out direct subsidy payments were also considered in the report (5). USAID also has published a report on "Evaluating Fertilizer Subsidies in Developing Countries" (4). Information on subsidies and economics

of fertilizer use provides a basis for a discussion on policy alternatives and tradeoffs.

Indirect Subsidies--The real price of fertilizer may be reduced in a number of ways other than direct subsidies. One of the most common ways is to make credit available to farmers at a subsidized interest rate. Subsidized credit programs may be effective in expanding fertilizer use in cases where lack of credit with reasonable interest rates is a major constraint. Although the allocative mechanism of the free market system does not necessarily operate perfectly, there is nevertheless a tendency for the free market to allocate capital to activities where the highest returns can be obtained. Hence, permanent subsidization of credit for fertilizer may involve a considerable cost to society because returns to limited capital are reduced. A less costly policy may be to remove the factors causing the high interest rates associated with credit for fertilizer purchase.

Risk and uncertainty in agricultural production and lack of credit security are probably the major factors causing such high interest rates and reluctance among commercial banks to provide agricultural credit. Government policy aimed at reducing the risk and uncertainty and providing additional security for the moneylenders in a way acceptable to the farmer is likely to provide higher benefits than subsidized interest rates.

It is difficult to assure that subsidized credit is in fact used for fertilizer purchases over and above purchases that would have taken place in the absence of such subsidies. Hence, the impact of such programs on fertilizer use tend to be much smaller than expected.

Other indirect subsidy programs include tax concessions, preferential exchange rates, preferential freight rates, etc.

The administration of subsidies and price policy is dealt with more fully in an FAO/FIAC report that is still (in July 1976) in draft form (6). This guide contains a comparison of the effectiveness of fertilizer subsidy programs, crop price support policies, and related measures. Thus it, like the preceding publications, applies not only to this subsection but also to some of the subsections that follow.

Price Differentiation--The contribution of fertilizer to agricultural production and development may be increased through a reallocation of available fertilizer among crops, regions, or other farm groups, e.g., food vs. export crops. Two-price systems (selective subsidies) have been applied in a number of countries

to accomplish such aims. Sometimes subsidies are limited to small farmers (Morocco and Korea). In other cases they are limited to producers of specific crops (Sri Lanka, Ivory Coast). And elsewhere differential pricing for fertilizer by type of crop has been applied (Sri Lanka, Philippines, and Uruguay). The difficulty of controlling the actual use of fertilizers, however, suggests that government intervention in product prices may be more effective.

Increasing Agricultural Product Prices

Agricultural price support policies are common in developing and developed countries. While some such policies aim at price stabilization (this item will be further discussed later), others are focused on increasing agricultural product prices above free market prices to stimulate production. Increases in product prices will make it profitable for the farmer to expand fertilizer use. However, while policies resulting in reduced fertilizer prices promote more agricultural products at lower prices, policies aimed at increasing product prices promote more but also more expensive agricultural products. When prices are above free market equilibrium between demand and supply, the latter policies tend to create a surplus of agricultural products. Such surplus must be removed from the market to maintain the higher price. While the cost of the higher prices is passed on to the consumer, the cost to government of surplus removal can be very high as experienced by the United States during the 1950's.

Many developing countries are faced with severe nutritional deficiencies among considerable proportions of the population, mainly due to lack of purchasing power. Furthermore, even where malnutrition is not a major problem, food costs occupy a large portion of the family incomes. In such countries, the level of food prices is of extreme importance in the development process. Under such conditions policies aimed at increasing agricultural product prices may not be in the best interest of the individual country if the price increase is passed on to the consumer as would usually be the case.

Increasing Agronomic Response to Fertilizer

The agronomic response to fertilizer depends on a number of factors including (1) soil characteristics; (2) climatical variables such as rainfall pattern; (3) irrigation; (4) plant variety; (5) disease and insect attacks; (6) the type and nutrient balance of the fertilizer; and (7) timeliness and form of application. Government policy aimed at increasing the response may focus on (1) research to improve fertilizer materials and

application methods; (2) research to modify the factors mentioned above; and (3) extension work to assist farmers in applying current knowledge, materials and methods aimed at improving fertilizer efficiency.

Research on Materials and Methods--Public funds are needed to promote research at the national or local level to identify more efficient fertilizer materials and application methods. Such work should be supported by international research on specific topics with applicability beyond national boundaries. International research is discussed in Part II.

Removing Constraints to Fertilizer Use

In addition to fertilizer and crop prices and agronomic response, fertilizer use is determined by the presence or absence of a large number of constraints. Such constraints may either reduce the profitability to the farmer of using more fertilizer, or prohibit the farmer from obtaining--or make it unattractive to him to seek--such potential profits.

The type of constraints and their relative impact on fertilizer use vary among geographical regions and among farm groups within regions. In general, small farmers tend to be faced with more severe constraints than larger farmers for a number of reasons to be further discussed.

Sound governmental policy aimed at removing constraints must be based on (1) knowledge of which constraints prevail among the farmers toward which the policy is aimed; (2) a thorough understanding of how such constraints affect fertilizer use; and (3) how the constraints interact. It is argued here that such knowledge and understanding is scarce in most developing countries. For these reasons, it is recommended that multidisciplinary research, including inputs from economics, agronomy, sociology, and possibly other disciplines, be carried out at the national or local level to obtain such information.

While the presence and impact of individual constraints are location specific, a number of constraints appear to be present in most developing countries. These include (1) unavailability of fertilizer where and when needed; (2) lack of knowledge; (3) risk and uncertainty; (4) lack of credit; (5) land tenure; and (6) lack of the most appropriate complementary inputs. Policy measures aimed at reducing the impact of each of these constraints are discussed below.

Unavailability--Although it is obvious that fertilizers must be available where and when needed to be efficiently utilized, this basic requirement is frequently not met. Policy measures in the area of fertilizer distribution, including the promotion of cooperatives, were discussed previously and need not be repeated here. It should be stressed here, however, that lack of the right kind of fertilizer at the place and time needed is currently limiting fertilizer use and efficiency in many countries. It is particularly important that any activities expected to increase fertilizer demand, e.g., price and credit subsidies, be accompanied by policies to assure sufficient increases in fertilizer availability to meet such demand increases. This is frequently overlooked. The results are fertilizer scarcities, black market developments, and limited impact of the demand expanding activities.

Lack of Knowledge--Farmers--and for that matter extension workers--are frequently poorly informed about the kind and quantity of fertilizer to use and how and when to apply it. Government policy is needed to support agronomic research to generate information adequate to guide farmers as to type of fertilizer needed, optimum quantities and timing, placement, etc., under various climatical, environmental, economic, and soil conditions. The results of such research should be put to use through close collaboration with farmers and extension agents. Individual experiments should be used to demonstrate to the farmer the economic return from increasing fertilizer use and to assist farmers in using improved practices and inputs other than fertilizers.

Since fertilizer response is very location and time specific it is recommended that small quantities of fertilizer be made available to farmers not currently using fertilizers, at subsidized prices, along with information regarding its use to facilitate on-farm trials and demonstrations.

Risk and Uncertainty--Risk and uncertainty may be caused by natural or environmental factors or by market factors. Rainfall patterns and disease and insect attacks are the most important natural or environmental factors causing risk and uncertainty. Such risk and uncertainty may be reduced through better management practices including the use of pesticides and irrigation or through the development and use of resistant varieties.

Government policy aimed at facilitating irrigation, developing and/or diffusing resistant varieties, making available pesticides, and improving crop management practices in general may have considerable impact on the use and efficiency of fertilizer.

Hence, it is important that government policy aimed at expanding fertilizer use be established in the broader context of agricultural production.

While fertilizer price fluctuations may affect the quantity of fertilizer used, they do not contribute much to risk because the farmer in most cases knows the actual price before purchasing, and hence can react accordingly. Agricultural product price fluctuations, on the other hand, introduce considerable risk and uncertainty because the investment in fertilizer must be made before the actual crop price is known. The economic optimum quantity of fertilizer varies according to the crop price and it is to be expected that the farmer faced with the experience of large crop price fluctuations will tend to limit fertilizer use to correspond with optimum quantities at relatively low crop prices. Government policies aimed at crop price stabilization may be very effective in expanding fertilizer use. The government cost of price stabilization programs for agricultural products need not be high if established at the right level. However, it is difficult to choose the right level because of uncertainty in future supply. Too high price levels will result in market surpluses while too low levels will result in scarcities.

Lack of Credit--Lack of credit is probably the one single constraint to fertilizer use most frequently mentioned by farmers. While this factor is undoubtedly important, it is argued here that results from farm surveys grossly overstate its importance. A large proportion of the farmers who state that lack of credit is the reason for not using or not expanding the use of fertilizer would probably not use fertilizer if provided credit. Lack of knowledge, risk and uncertainty, and the unwillingness to take the consequences of not being able to repay the credit from the incomes generated by the crop to which the fertilizer was applied are frequently the real reasons why credit is not sought and obtained.

Subsidized credit programs were discussed previously. It appears that governmental policy is needed in many countries to provide sufficient guaranties to the moneylenders and limit the consequences to the farmer of crop failures. Government supported crop and credit insurance programs might be effective.

Land Tenure--If ownership of the crop and ownership of the land on which it is produced are placed with the same person or family, fertilizer use tends to be larger than if land and crop ownerships are separated. Tenant farmers in some countries may be required to pay for all inputs including fertilizer and deliver a portion of the crop to the landlord. Hence, the tenant gains only

part of the return on his fertilizer investment which, in turn, means that the economic optimum quantity of fertilizer is smaller than if the farmer is also the landowner. Governmental policy aimed at promoting or forcing cost as well as output sharing between tenants and landlords would be expected to increase fertilizer use and agricultural production. Likewise, of course, land reform policies resulting in a shift from tenancy to ownership by the farmer who grows the crop would expand fertilizer use, other things being equal.

The benefits of fertilizer usually extend beyond one cropping season. Hence, short term tenancy arrangements and uncertainty about future arrangements tend to reduce fertilizer use because of the uncertainty as to who will reap the benefits of fertilizer beyond the cropping season for which it was initially applied. This same problem exists where government plans call for land reform and redistribution in the near future. Whether such plans will in fact materialize or not, they tend to create sufficient uncertainty among larger landowners to reduce investment in fertilizer and other land improving activities. Governmental policy aimed at facilitating longer-term tenancy arrangements and reducing the uncertainty concerning land ownership would probably result in expanded fertilizer use and increased agricultural production.

Lack of Complementary Inputs--The importance of irrigation, pesticides, herbicides, and other production inputs and management practices to reduce risk and uncertainty was mentioned above. In addition to their impact on risk, these factors are important determinants of total fertilizer response. Varietal improvement is probably even more important. Fertilizer response is far greater among improved rice and wheat varieties than among traditional ones, for example. While such increase in response is a genetic characteristic (related to dwarf varieties and corresponding reduction in lodging) the farm level response may be further increased relative to traditional varieties if they are more resistant to certain diseases and insects. Governmental policy aimed at (1) promoting research on varietal improvement; (2) testing and modifying improved materials from international and national agricultural research; and (3) diffusion of improved materials to farmers are likely to be effective in expanding fertilizer use and agricultural production.

Manpower Utilization and Training

All countries have three major types of resources that must be managed--capital resources (money and negotiable assets), physical resources (land, property, and equipment), and human resources (people). The human resources are the most important because management of the other two depends entirely on the effectiveness of human resource management. All governments are deeply involved in human resource development; not all governments have formalized policies.

National Human Resource Inventory

If a country or government is consciously involved in people development it should have reasonably good information about its population. Such information will include but not be limited to: (1) total population, (2) age distribution of population, (3) location or distribution (geographic) of population, (4) education level, (5) skill classifications, (6) size of work force, (7) distribution of work force by industry, and (8) population trends. Information of this type provides a base of information for decision making within various industries of a country. For example, it may be unwise to plan to build a fertilizer factory to utilize indigenous physical resources if workers with appropriate skills are not available or cannot be developed to operate the factory effectively. If the decision is made to build a factory such a decision, by policy, implies that the necessary training and development programs will be made available and/or the type of factory to be built will be influenced by manpower supply and their skills.

National Industry Manpower Distribution

From a policy such as that described above another policy evolves naturally; that is, to do those things necessary to stimulate the movement of appropriate numbers of people and the link of skills to industries so that national goals can be met. In countries that favor private sector, national policy is such that workers will flow to effective industry demand. In countries that have formal national plans workers may be directed by edict. In actual practice most countries have policies somewhere between laissez-faire and total control. Practices and procedures emanating from such policies might be:

1. Establishment of quotas of people assigned to an industry.

2. Establishment of special training and development programs to prepare people to move from one industry to another, or from the educational systems to industry.

3. Incentives to an industry to stimulate movement of people from one industry to another and/or movement of people geographically.

Industry Personnel and Training

From policies such as the two previously listed, a logical next step is to have a policy that each major industry will acquire and develop a work force consistent with the needs and aspirations of the industry and compatible with the country's best interests. Some practices and procedures that would be appropriate to the fertilizer industry are:

1. Advance planning is needed to ensure that well-qualified personnel will be available when and where needed. This should be valid whether people are nationals or ex-patriates.

2. Training programs should be developed that will ensure continuous and competent manning of the organization. Such programs will include:

   a. Management and supervisory training programs.

   b. Extension programs for dealer and farmer education.

   c. Skills training programs for technicians, plant operators, maintenance people, etc.

   d. Marketing programs including distribution, promotion, and sales when and if appropriate.

   e. Definite commitments to and from foreign organizations about work force development so that they will be able to plan programs without the fear of being terminated in mid-program. (This will avoid high built-in costs to prevent losses and assure that a work force will be trained.)

3. Specific personnel policies and/or practices should be developed to encourage efficiency and provide incentives. Examples are:

a. Prepare position descriptions that clearly define the work to be done.

b. Compensation programs that provide competitive pay and fringe benefits.

c. Incentive plans that are challenging and reachable based on standards of performance that are mutually acceptable.

d. Communication to work force of alternate paths for advancement.

e. Anticipate and project job opportunities for the future (avoid "craft complex" which assures workers obsolescence over time).

In summary, suggestions for government and fertilizer industry policies related to human resource management are:

1. Develop and maintain a valid national human resource inventory.

2. Develop a national system to assure that appropriate human resource will flow to industry segments as needed.

3. Each major industry will acquire and develop a work force consistent with needs of the industry and compatible with country's best interests.

4. Establish clear personnel policies that will provide incentives for efficient job performance.

Investment and Financing

It has been estimated that for the developing countries as a group to attain fertilizer production self-sufficiency by the year 2000 the capital investment in major nitrogen and phosphate plants would amount to over $\$50 \times 10^{9}$ over the period 1980-2000. (This figure is based on the value of the U.S. dollar in December 1975.)

Additional costs will be involved in mining and beneficiation of raw materials and potash salts, in distribution and transportation facilities, and in infrastructure. The total

capital requirement is difficult to estimate, but it is likely to be well over $\$100 \times 10^9$ for developing countries as a group for 1975-2000.

In reviewing case histories of cooperative financing of several fertilizer plants in developing countries, it is evident that loans and grants have played a large part in financing many of these plants. Often the loans are on concessional terms, as to interest rates and repayment schedules. Also, it is evident that financing of this type may be inadequate for future expansion of the fertilizer industry in developing countries on the scale projected. Therefore, it seems likely that more investment financing will be required in the future. The purpose of this section is to suggest governmental policies that will encourage foreign and domestic investment in new fertilizer plants. Some of the policies suggested should also be helpful in obtaining loans from the World Bank or regional banks; a sound, viable project may well attract both investment capital and supplemental financing from lending agencies.

Investment capital may be classified in two general types: loans (bonds or debentures) that pay a fixed rate of return, and equity capital in which the rate of return depends on the profitability of the enterprise. The investor may not necessarily expect to receive his return directly in the form of cash. For instance, farmers, cooperatives, and plantation owners may invest to ensure a supply of fertilizer at a reasonable price. Their return may consist of a system of rebates or discounts on fertilizer used. Foreign organizations or governments may invest for the same reason. Raw material suppliers may invest to ensure a profitable market for their product (natural gas, phosphate rock, sulfuric acid, etc.). In this case the investor expects to make at least a part of his profit from sale of raw material.

It is self-evident that investment capital can be attracted only when the investor expects to receive a return on his investment (direct or indirect) that is higher or more certain than alternative uses of his capital. This means that the investor must expect the operation to be profitable. Therefore, governmental policies discussed previously that permit and encourage plant operation at maximum capacity and minimum production cost are very pertinent to inspiring investor confidence. Maximum freedom to make decisions by management of the producing organization is particularly helpful. Such freedom implies minimum control by government consistent with national objectives. Even when the manufacturing organization is partly or wholly owned by the government, it can function most efficiently

when it has maximum autonomy and minimum fragmentation of responsibility among other government agencies.

Frequently, a useful means for attracting investment capital is through joint ventures. The partner in the joint venture may be a foreign company or government, a domestic organization, or a transnation corporation. This arrangement is particularly helpful when the partner can supply technical or management skills and experience as well as a guaranteed source of raw material and/or a market for products.

Another way to attract investment capital and expertise is by means of a product-sharing agreement. This method is often used for exploration and development of mineral resources, especially natural gas and petroleum, but it can apply to fertilizer production as well.

In either joint ventures or product-sharing agreements, care must be taken to ensure that the terms are consistent with national strategies and policies. However, several developing countries have found such arrangements helpful and satisfactory and have worked out types of agreements that are mutually beneficial. It is suggested that developing countries that have had little experience in dealing with foreign organizations should make use of the experience of those countries that have had such experience.

Incentives to Investors Through Tax Laws or Concessions

Manipulation of tax laws offers numerous opportunities for encouraging (or discouraging) investors. The types of taxes involved include individual and corporate income taxes, import and export duties, severance taxes on raw materials used, sales or excise taxes on materials sold, payroll taxes, and many others. Following are some ways that tax laws can be used to attract investors or joint venture partners.

1. Partial or complete exemption of interest on bonds, debentures, or on dividends from fertilizer manufacturing operations from individual or corporate income tax.

2. Tax holidays permitting new plants to operate a specified number of years without or with reduced property or income tax.

3. If the organization owns and uses indigenous raw materials, it may be permitted to charge a depletion allowance as an operating expense, thereby decreasing taxable income. In

theory, this allowance compensates the company for the diminishing value of its raw material resource and encourages exploration for additional resources.

4. Development rebates may be provided based on contribution to local or national economy, or on development of natural resources.

5. Exemption from severance taxes or excise taxes on raw materials used.

6. Exemption from import duties on imported plant equipment, imported raw materials, spare parts, and supplies.

7. Exemptions or concessions on export taxes on fertilizers if necessary to make the products competitive on the world market. Encouraging export of production in excess of domestic needs will help keep the plant operating at a high percentage of its capacity and thereby lower production costs.

8. Allowance of rapid depreciation rates for tax purposes may be used to stimulate investment. This offers the investor a prospect of relatively rapid recovery of his investment.

Careful consideration should be given to the effect of these concessions on the national economy before reaching a decision.

Nationalization of Industry

The possibility that the government may nationalize a fertilizer plant is a strong deterrent to investors. This deterrent effect can be minimized by a guarantee of full compensation in case of nationalization. However, there is always the possibility that a guarantee by one government will not be honored by a subsequent government. Therefore, the stability of the government is an important factor. Guaranties of foreign investment may be supplied by international institutions (USAID, World Bank, etc.).

Export of Profits or Capital

Quite often potential foreign investors are not interested in situations that severely restrict recovery of their profits in their own currency. Therefore, a guarantee that export of profits will be permitted will be an encouragement to investors. A similar situation applies in case the investor decides to sell his

equity in the fertilizer plant, or is forced to sell his equity by government policy.

Before investing in a new fertilizer plant, the investor must be convinced that there will be a profitable market for the plant's products, either for domestic sale or export, or both. In a free economy this decision will be the investor's responsibility. He will probably seek advice through market research and forecasts.

If the government controls the price or if the government assumes responsibility for marketing, the investor will need some assurance that government policy will result in a profitable market. In either case, there should be a well-defined agreement that will result in a fair, but not excessive profit. The agreement should be such as to provide an incentive for efficient operation of the plant and should be flexible enough to provide adjustments for increased (or decreased) cost of raw materials, labor, and other factors beyond the control of the producers.

When part of the production is intended for export, the producer should have sufficient freedom to make long-term contracts and to meet competition in the world (or regional) market.

Concessions for Exploitation of Resources

When a country has natural resources, it may grant concessions to develop and exploit these resources to foreign or transnational companies on the condition that the company build and operate a fertilizer plant. This arrangement may be particularly appropriate when exploitation of the resource yields a product or byproduct that is usable as a raw material for fertilizer manufacture. For example, a company may be given a concession to develop a petroleum reserve on condition that the associated natural gas, which might otherwise be flared, be used to produce nitrogen fertilizer. A concession to exploit a phosphate rock deposit might be tied to manufacture of phosphate fertilizer. Concessions to exploit metal sulfide ores (zinc, copper, lead, nickel, etc.) might require that the ores be processed within the country to recover sulfuric acid or sulfur for fertilizer manufacture. Byproduct pyrites associated with such ores might also be utilized. This sort of conditional concession could be extended to include resources unrelated to fertilizer (e.g., bauxite).

It should be noted that if the fertilizer operation is not profitable in its own right, the company is likely to neglect it.

Also when the raw material from one operation is a byproduct from another, the rate of fertilizer production may be governed by the operating rate of an unrelated industry. This disadvantage can be overcome, in some cases, by storing or stockpiling materials such as sulfur or pyrites.

In summary, investment capital must be attracted to help developing countries attain self-sufficiency in fertilizer production and to utilize their resources advantageously. Government policies needed to achieve this result are:

1. Those policies which permit and encourage efficient operation of production facilities.

2. Policies that permit joint ventures, concessions, or partnerships which often are the most effective means for attracting foreign capital and the foreign expertise that are usually needed for successful operation.

3. Marketing policies must not preclude profitable operation. However, there are examples of successful tie-ins of foreign investment and government distribution of fertilizers.

4. Tax laws or tax concessions that can attract foreign investment and ensure participation of foreign experts or technologists necessary to successful and efficient project management.

PART II—THE ROLE OF INTERNATIONAL ORGANIZATIONS

Introduction

At various points in this report, mention has been made of the areas in which developing countries may well need assistance in planning and carrying out the development and expansion of their fertilizer industries. The intent of this section is to suggest some policies that international agencies should adopt to guide, assist, and support developing countries in achieving the goals set forth.

Policies cannot be separated from activities; policies define the direction, extent, and goals of activities. Therefore, this section will deal primarily with suggested areas of fertilizer-related activities that are necessary and appropriate for international organizations.

International organizations may be classified by type as:

1. United Nations and its affiliated organizations, including UNIDO, FAO, and United Nations Commission on Trade and Development (UNCTAD); the World Bank; and various affiliated regional or special-purpose organizations.

2. Inter-governmental organizations not affiliated with the United Nations, such as Organization of Petroleum Export Countries (OPEC), Organization of American States (OAS), Asian and Pacific Council (ASPAC), Association of Southeast Asian Nations (ASEAN), and Central Treaty Organization (CENTO).

3. Industry organizations including organizations supported by or serving industry for commercial, educational, information exchange, and/or scientific purposes. Examples are: World Phosphate Industry Association (ISMA), the Potash Institute, The Sulphur Institute, Centre d'Etude de l'Azote, NITREX, Phosphate Rock Export Association (PHOSROCK), etc.

4. Organization of individual governments whose aim is to assist developing countries. Examples are: USAID, Kuwait Fund for Arab Development, and Canadian International Development Agency (CIDA).

5. Nongovernment organizations for international research and development which may be supported entirely or in part by private foundations and/or donor governments. The Consultative Group on International Agricultural Research and its member international centers and IFDC are examples.

In general, these international agencies can and do perform useful functions that are beyond the interest or capability of individual governments; they promote cooperation between countries, provide centralized sources of information, and avoid unnecessary duplication of effort. It is beyond the scope of this chapter even to list, much less discuss, all of the fertilizer-related activities that international organizations carry out. The intent is to mention and briefly discuss some areas where additional emphasis or support to developing countries is needed. Failure to mention any particular activity should not be construed as an inference that the activity is unimportant.

Research and Development

Development of Materials and Practices to Improve Efficiency of Fertilizer Use

The purpose of this section is to suggest ways that international agencies can improve the efficiency of fertlizer use through research and development, particularly through new or improved fertilizer materials and practices. Efficiency is seldom an intrinsic property of a fertilizer material; more commonly improvements result from some combination of fertilizer properties with application practices. Unfortunately, there has been too little communication, cooperation, and coordination between fertilizer technologists (chemists and engineers) who develop new products and agriculturists and economists who evaluate new products or perceive the need for improved products. It is strongly recommended, therefore, that closer collaboration between diverse disciplines receive a high priority in future research and development.

Improvement of efficiency of fertilizer use is a goal that should receive top priority, not only in research and development

but also in application of current knowledge. The average efficiency of nitrogen use by grain crops is not precisely known, but 50% is a frequently mentioned figure. In the case of paddy rice, the average is almost certainly lower and often as low as 25%. Losses of nitrogen occur by leaching, runoff, decomposition, and volatilization as elemental nitrogen, ammonia, or nitrogen oxides.

If the average recovery of applied nitrogen by crops is now 50%, increasing the recovery to 60% would mean that crops would receive 20% more nitrogen from the same amount of fertilizer, or alternatively the amount of nitrogen applied could be reduced by 16.7% for a given crop uptake. Assuming that the increased efficiency were used to reduce fertilizer requirements, the reduction might amount to 27 million tons of N per year by the year 2000 on a worldwide basis. Assuming a farm cost of $350 per ton, the annual saving would be near $10 billion.

There is some reason to suppose that the average nitrogen efficiency is substantially below 50%, especially in developing countries. Most estimates are based on experiments at farms or agricultural stations where practices and conditions are carefully controlled at near optimum levels, except for the variable under study. It is suggested the average farmer in developing countries may attain a much lower nitrogen efficiency than 50% owing to the following factors:

1. Unbalanced fertilization. Nitrogen efficiency can fall below 10% due to deficiencies of other elements. Naturally, unbalanced fertilization can impair the effectiveness of any applied nutrient element, but overemphasis on nitrogen is common in many developing countries.

2. Poor timing of application or poor placement.

3. Poor irrigation practices or lack of water control, including droughts and floods.

4. Poor choice of type of nitrogen fertilizer, or unavailability of types best suited to tropical agriculture.

5. Use of unresponsive crop varieties.

6. Poor cultivation practices, including ineffective weed control.

7. Lack of plant protection from disease and pests.

In view of the large number of possible means for improving the efficiency of nitrogen use, a goal of 20% improvement (such as increasing efficiency from 50 to 60%, or from 25 to 30%) seems realistically attainable, and perhaps overly conservative. Much improvement could result from application of present knowledge. This is basically the responsibility of individual governments although international agencies can and do assist.

One promising area for research on improving nitrogen use efficiency is the field of controlled-release materials. The object is to decrease losses by leaching, runoff, or volatilization by releasing nitrogen to the soil solution gradually in accordance with crop needs. It is beyond the scope of this chapter to review the numerous studies of production and use of controlled-release nitrogen fertilizers. Perhaps it will be sufficient to point out that a very substantial improvement in nitrogen efficiency (often as much as 30%) has been demonstrated in experiments with rice and other crops in Peru, Korea, Taiwan, and numerous other countries. The main problem is the higher cost of controlled-release materials. Sulfur-coated urea appears the most likely to yield benefits in excess of its cost on food crops. The results to date appear to justify further study.

Another method for improving efficiency of nitrogen use by paddy rice is deep placement (10-15 cm below the soil surface) of urea or ammonium sulfate at the proper distance between rows. Experiments by the International Rice Research Institute (IRRI) have shown that this placement substantially improves yields and nitrogen use efficiency. The mechnical difficulties or expense of achieving this placement with prilled urea led to experiments with large granules or briquettes (1-4 g) of urea, which proved easier to use and effective. The cost of producing such granules or briquettes is being evaluated.

Numerous experiments have shown that foliar application of nitrogen and other nutrients can be more efficient in certain cases than application to the soil. However, there are many drawbacks and/or limitations. Recent experiments in the United States and Brazil have shown that foliar application can dramatically increase the yield of soybeans and some other grains. Timing of the applications is critical; it must be during the formation and development of seed. Solution composition is also critical; it must contain N, P, K, and S in definite ratios which depend on the crop. High soil fertility or adequate soil fertilization is also necessary. Calculations indicate in some cases the nitrogen content of the increased yield of grain is

approximately equal to the nitrogen applied in the foliar application. It would appear, therefore, that the efficiency of nitrogen use (and presumably that of other elements) approaches 100% for that portion of the fertilizer that is applied to the leaves. The success of this system will depend in part on the development of economical methods for production of suitable materials for compounding the solutions for foliar application. Ammonium or potassium polyphosphate appears to be an essential or at least highly desirable component; the latter is reported to be preferable.

The efficiency of phosphorus fertilization is a much more complex subject than nitrogen efficiency. It is often stated that the efficiency of phosphorus fertilization seldom exceeds 25% and often is as low as 10%. This statement requires amplification. It means that one year's or season's crop recovers 10-25% of the phosphorus applied in that year or season. Unlike nitrogen, the remainder is not lost (unless by erosion) but stays in the soil and becomes soil phosphorus. (In extremely sandy soils, and some organic soils, loss by leaching is possible.) Thus, the cumulative effect of continued phosphorus fertilization is to build up the fertility of the soil to the point that the crop takes up most of its phosphorus from the soil and relatively little from freshly applied fertilizer. However, over the entire period, the total amount of phosphorus recovered by crops may approach the amount applied as fertilizer. Thus in one sense, phosphorus fertilizer efficiency may approach 100% over a long period of 25-100 years.

There are two main opportunities for improving phosphorus efficiency. In developing countries the level of phosphorus is often very low and farmers can seldom afford the massive application or long period of annual applications that may be necessary to build up the fertility of the soil. There is a need, therefore, to develop phosphate materials that will be more effective in the year of application. The other opportunity is in the case of farms with a long history of fertilization; in such cases it may be possible to decrease phosphorus application without decreasing yields provided the level of residual phosphate is high. In fact, in some developed countries it has been demonstrated that phosphorus application can be omitted entirely for up to 5 years without affecting yields appreciably. Also, for maintenance of soil fertility, less soluble and less expensive phosphate sources may be adequate.

Many soils in developing countries are strongly acid, low in available phosphorus, and high in phosphate fixation capacity. Application of limestone is helpful, but an economical supply is

not always available. It is known that in such situations, efficiency of soluble phosphates is improved by granulation, but little information is available as to optimum granule size or placement for many tropical soils. Also, some water insoluble phosphates have given better results or higher value:cost ratios than soluble phosphates in some tropical soils. Examples are ground phosphate rock for direct application, phosphate rock sintered with soda ash (Rhenania phosphate) and phosphate rock fused with olivine or serpentine (calcium magnesium phosphate). The liming effect of these materials or secondary nutrient elements may also contribute to their effectiveness. These examples should serve to stimulate research on other, less expensive phosphates that may be more effective on tropic soils.

When new lands are developed by governments for agriculture, the government might well consider a basic application of phosphate or lime or both as a part of reclamation cost. Such costs could be viewed in the same light as other reclamation costs; clearing, irrigation, or drainage of swampy areas. For acid soils, the basic application might economically be supplied as ground rock phosphate. Often, even small domestic deposits could be utilized.

Efficiency of potash fertilization may be in the range of 40-45% according to some sources. However, in many soils, potash not used by one crop remains in the soil and may be used by later crops. On the other hand, losses of potash by leaching are fairly common on soils of low cation retention capacity, or on coarse-textured soils in areas of high rainfall. In these cases, slow-or controlled-release materials may be useful in improving efficiency. Examples are coated soluble potash salts and slightly soluble compounds such as $KMgPO_4$. Also, crops tend to take up more potash than they need when the supply is adequate (luxury consumption). This excessive consumption does not increase the quantity or quality of yields and hence is inefficient use. Luxury consumption may be controlled by proper control of quantity and timing of applications, or by use of controlled-release materials. However, there is a need for research in this area.

Deficiencies in other elements (Ca, Mg, S, Zn, B, etc.) can be just as disastrous to crop yields as deficiencies of major nutrients, and can cause inefficient use of major nutrients. The principal research needed at present is more information about the extent and location of needs. When this information is at hand, there may be a need for research on the most efficient means for supplying the needs.

Sometimes deficiencies can be corrected by application of limestone which may increase the availability of the native soil supply of the element in question. Each nutrient element has a pH range in which its availability is at a maximum; so liming to alter the pH must be done carefully to avoid decreasing the availability of some elements.

The development of new varieties of high yielding food crops has contributed substantially to increased food production. These varieties are more responsive to fertilizer. Research and development on plant breeding and adaptation should continue and should be accompanied by studies of methods of improving fertilizer efficiency. Development of disease-resistant varieties also will help improve fertilizer efficiency.

Development and improvement of food crops that fix nitrogen symbiotically will help decrease the need for chemical nitrogen fertilizers. Successful development and wider use could have a major impact on world nitrogen requirements. However, the need for phosphorus and potassium fertilizers would not be reduced and might be increased. Again, this activity should be accompanied by studies of methods for utilizing chemical fertilizers with maximum efficiency.

Research and Development to Reduce Raw Material, Manufacturing, Distribution, and Application Costs

It is well known that transportation, handling, storage, and bagging of fertilizers from factory to farm and of raw materials from source to factory make up 30-50% of the farm cost of fertilizers, and in some remote regions may be much higher. Economical processes have been developed and are in use for producing such high concentration materials as diammonium phosphate, urea, and refined potassium chloride, which tend to minimize these weight-related costs per unit of plant nutrient. There is scant prospect of substantial further improvement through research and development. Perhaps development of economical processes for producing potassium phosphates is the most promising future possibility.

More consideration should be given to direct application of anhydrous ammonia (or aqua ammonia) in developing countries. Anhydrous ammonia has been demonstrated to be the lowest-cost form of nitrogen at the farm level in the United States and some other countries for those soils that are suitable. This possibility usually is dismissed out of hand as "too sophisticated" for most developing countries. This is probably true at present, but should not remain so indefinitely. Admittedly the cost of

facilities for distribution, storage, and application of anhydrous ammonia are high, but so are facilities for converting ammonia to urea, and for transporting, storing, and bagging it. Also energy consumption is higher for producing urea.

A substantial opportunity for decreasing fertilizer cost to farmers in developing countries through research and development lies in selective production and use of lower analysis materials. The precept of high analysis has been too well learned, to the point that officials of developing countries automatically accept it as a mark of advanced technology; any lower analysis materials stigmatize the industry as backward. Lower analysis materials may well be less expensive when they can be made in simple equipment from indigenous raw materials for local use, particularly for remote countries or regions where the alternative of transporting imported high-analysis materials (or raw materials to make them) over poor roads is very expensive. Also, some low-analysis materials contain secondary elements that may be fully as important for local farmers as the primary nutrient element. For instance, the farmer is not benefitted by a saving in cost of phosphate fertilizer obtained through high analysis if he must then purchase expensive sulfur or calcium materials that might have been supplied in a lower analysis phosphatic material.

Wider Use of Low-Technology and Small-Scale Plants

Large-scale, complex modern plants are not always the best answer to the problem of fertilizer supplies in developing countries. While the cost of production for most processes decreases as the scale of the plant is increased, it does not necessarily follow that the cost to the farmer is decreased. Also, the economies of scale depend on the process selected, on labor costs, on raw material supplies, and the probability that the plant will be operated at or near capacity.

There should be a place for small, simple plants in many remote countries or regions where requirements are small, transportation costs are high, labor costs are low, and key raw materials are available. Small deposits of raw materials can be utilized economically. The grade of the local raw material may be less important for local distribution and use.

A classic example of successful use of low-technology fertilizer production is in China. Hundreds of small ammonia plants are in operation using local coal as feedstock. The ammonia is converted to low concentration aqua ammonia or ammonium bicarbonate for local use. There are also several hundred small phosphate plants; many of them are thought to be based on local

deposits of phosphate rock, which is sometimes low-grade. Little information is available about types of technology. It appears that some of the plants merely grind phosphate rock for direct application. Others produce fused calcium magnesium phosphate in shaft furnaces resembling blast furnaces, presumably using local coal or coke as fuel. Still others produce single superphosphate using byproduct sulfuric acid, and a few make triple superphosphate. Potash is recovered from underground brine, from an alkaline lake, and as a byproduct of coastal evaporation salt works.

Although China is now building large nitrogen plants, the small, local plant concept served well during a stage of development and still supplies a major portion of fertilizer needs (7).

The success of the Chinese system may depend, to some extent, on a degree of government control of labor and industry that may be unacceptable in some other countries, but there are valuable lessons to be learned. It is suggested that international organizations adopt a policy of carrying out research and development in appropriate areas and promoting low-technology, less capital-intensive processing in countries whose needs may best be served in this way.

What is needed from international agencies initially is the financial backing to examine some example situations in this context, develop some flowsheets and equipment requirements, and demonstrate the processes in small-scale units, or, if possible with present data, translate the data into a working plant.

Such a policy is difficult to move toward since the current policy favors the large capital-intensive production units with complex marketing systems, often involving export. With a given technology, it is easy to demonstrate economy of scale, but the degree varies by process. Therefore, it is necessary to select process alternatives and products that are not so sensitive; i.e., raw materials account for a major portion of the cost. Low-capacity utilization will not significantly increase the cost. Such processes are known to exist.

The adoption of low-technology, low-capital type fertilizer plants should be one way of assisting some developing countries in achieving a higher degree of self-sufficiency in fertilizers and thus in food production. There are examples where this approach has been used and appears to be the rational way for these countries to proceed. Since many of these situations may not be

attractive to investors and because most developing countries do not have the expertise, international agencies would seem to be a logical group to become involved. To do so would require some adjustment in policy for many of them and certain changes of standards under which large fertilizer projects are now justified. Without some help in this area, many of the developing countries will not be able to make use of the limited resources they possess.

In summary, following are some areas in which research and development can help to decrease capital costs and costs of fertilizer at the farm level.

1. Development of small, simple ammonia plants to use local feedstocks, perhaps with local distribution of ammonium bicarbonate and/or dilute ammonia solutions.

   This project might build on the experience in China with improvements and adaptations.

   Development of small, semi-portable ammonia plants could help meet the needs of some developing countries. Such plants may be of standardized design; they may be mounted on skids or barges so they can be moved from one location to another. These factors help reduce the cost and time required for plant construction. While the capital cost and manufacturing cost is higher per unit of nitrogen for small plants than large ones, the difference may be offset by lower transportation and feedstock costs in many cases. The small, portable plants could take advantage of small pockets of natural gas which might otherwise be difficult to utilize economically. They should be particularly useful in remote regions where the demand is small and the alternative of importing nitrogen fertilizers is very expensive.

2. Use of phosphate rock (indigenous or imported) for direct application. This activity could substantially decrease both capital and operating costs in countries where soils are suitable. Research needs include agronomic, economic, and chemical studies of various rocks and methods of preparation (grinding, granulation, slurrying, partial acidulation).

3. Thermal methods for alteration of phosphate rocks with or without additives. Numerous methods have been identified and some have been developed that improve the phosphorus availability of phosphate rocks.

4. Studies of problem phosphate ores to develop improved beneficiation methods or adapt them to use in selected processes without beneficiation.

5. Improved methods of recovering potash from low-grade ores such as carnallite, kainite, and polyhalite.

6. Direct application of low-grade potash ores, both soluble and insoluble.

7. Study of indigenous sources of secondary and micronutrient elements to determine economical methods of utilization. This activity should be coordinated with agronomic needs.

8. Study of the social benefits and costs of incorporating appropriate technology programs into development plans.

More Effective Use of Rural and Urban Wastes

Materials usually classified as organic wastes include crop residues, animal manures, urban wastes (sewerage, trash, and garbage), waste forest products (sawdust, bark, twigs, leaves, etc.), food processing wastes (slaughter house waste, hulls from grains, fish scrap, whey, etc.), and wastes from processing non-food products (brewery waste, cotton hulls, tobacco stems, paper mill waste, etc.). The total of these wastes in developing countries has been estimated by the World Bank to contain six times as much N, P, and K as was used in the form of inorganic fertilizers.

The classification of all of these materials as wastes may be misleading. Many of them are regarded as valuable materials, particularly in developing countries. In fact, visitors to developing countries are often impressed by the extent to which such materials are utilized and the near absence of wastes.

In the early history of the fertilizer industry, extensive use was made of materials such as fish scrap, slaughter house waste, bones, cottonseed meal, and hulls. Now most of these materials find higher value uses. Crop residues are commonly left in the field in developed countries; in developing countries, crop residues are more likely to be used for fuel, fodder, or building materials. In some countries even cattle dung is more often used for fuel than fertilizer. Presumably the ashes from burning crop residues, bush and tree parts, and dung contains the mineral nutrients present in the original materials, but the nitrogen is lost. The farmers evidently consider utilization of the fuel value more important than recovery of the nitrogen for fertilizer

use, and probably rightly so. In areas where fuel shortage is less acute, animal dung is generally returned to the soil either by collection and distribution or by natural processes. Recycling manure merely returns to the soil nutrients that were derived from it, but sometimes in a more available form or at a more advantageous location. In general, there seems to be little opportunity for greater utilization of rural wastes, although there may be opportunities to utilize it more efficiently. One such possibility is anaerobic fermentation to produce methane with utilization of the residual for fertilizer. This method holds promise of recovering both the energy values and fertilizer values. The process is the basis of "bio-gas" plants which are said to be increasing rapidly in number in India. Anaerobic fermentation may also produce methane in sanitary landfills, and collection of substantial amounts of methane from this source is claimed to be possible.

Utilization of organic wastes for methane production apparently is already well advanced in China; it is reported that over 400,000 "marsh gas pits" located in nearly 1,000 counties produce methane-containing gas by fermentation of night soil, garbage, grass, stalks, and other organic materials (8). The gas is used for rural cooking, lighting, and heating, and even as fuel for small cement plants. Presumably, the residue is used for fertilizer.

The main opportunity for greater utilization of fertilizer values in waste materials appears to lie in methods for utilizing urban waste: sewerage, garbage, and trash. Unfortunately, the technical and economic problems are formidable. Urban waste contains pathogens that must be destroyed to prevent spread of disease. Heating by drying or composting of the waste under properly controlled conditions destroys pathogens, but the nutrient content of the compost is so low that it is seldom sufficient to pay the cost of transportation to farms. Some municipalities have profitably sold dried sewerage sludge for fertilizer or soil amendment. However, the market consists mainly of home gardeners who perceive some unique value in organic sources of fertilizer, which has not been confirmed by scientific data. So the use of urban wastes as fertilizers seems generally unprofitable, either to the producer or consumer. There are exceptions when properly treated town wastes can be utilized in immediately adjacent agricultural areas. Even then there is some danger that repeated application of the large quantities of urban waste which would be required for adequate fertilization may result in toxic accumulations of metals, such as cadmium, mercury, chromium, zinc, or copper. The concentration of these elements in

urban wastes varies widely from one municipality to another but is often quite high in relation to the plant nutrient content.

Utilization of urban waste could be maximized by a policy of decentralized urbanization: establishing many small urban centers rather than a few large ones. This system would increase the area within economic transportation distance.

At present, environmentally acceptable means for disposal of urban wastes are sanitary landfills or incineration. Incineration is gaining in importance, although more expensive, as sites for landfills are used up. Incineration provides opportunities for recovery of energy, although facilities for preventing atmospheric pollution are expensive. Perhaps the possibility of recovering plant nutrients (particularly phosphorus and potassium) from incinerator ash should be studied.

In summary, the research on improved utilization of rural and urban waste is worthwhile and indeed necessary from an environmental viewpoint. However, it is not expected to have a substantial impact on fertilizer supply in the foreseeable future. Agricultural waste is already being utilized fairly efficiently, although not always for fertilizer. Perhaps the most promising prospect lies in recovering energy more efficiently, including ammonia feedstocks. One can even visualize growing vegetative crops solely for methane generation at some future date. This would increase fertilizer demand, but provide feedstock for producing it.

Promotion and Demonstration of Fertilizer Use

In Part I of this report, policies of individual governments were suggested to promote the proper use of fertilizers through research, field tests, demonstrations, and educational programs. International agencies can and do assist in these activities.

Foremost among international agencies is FAO, which promotes fertilizer use and determines fertilizer requirements in many ways, including soil appraisal and fertility programs, to determine suitable application and other cultural requirements for particular soils and crops, aiming not only at higher yields, but also at optimum economic returns and farm profit.

The fertilizer-related activities of FAO have been summarized by F. W. Hauck.[5] The well-known FAO fertilizer program that was initiated in 1960 under the Freedom from Hunger Campaign deserves special mention because of its successful impact on fertilizer use in many countries. The United Nations Development Program (UNDP) also carries out fertilizer development programs. Many other international agencies of individual governments and nongovernment institutions participate in this type of work. For instance, IRRI has recently decided to adopt a policy of emphasizing research to improve the efficiency of fertilizer use on rice.

Perhaps there is a need for better coordination and cooperation among the numerous international agencies and institutions that attempt to assist developing countries in agricultural development in general and fertilizer use in particular. Sometimes the results of the work seem contradictory and confusing. It sometimes happens that the fertilizer programs attempt to transfer the techniques of developed countries to developing countries. The results are not always helpful. One reason is that developed countries are mainly in temperate zones while developing countries are located mainly in tropical or subtropical areas. Thus, soils and climates may be quite different. Also, sophisticated techniques that are useful in developed countries may not be helpful in some developing countries.

Technical Assistance and Training

Policies of international institutions should be concerned with getting technology into practice; such policies and the practices and programs that evolve should support the mission of the institution involved.

Manpower Training and Development

International institutions should assist individual countries (and/or groups of countries when needs are compatible) to meet manpower requirements for effective production, marketing, and use of fertilizer. It is necessary to be mindful of the fact that an

5. F. W. Hauck. "Identification and Development of the Fertilizer and Pesticide Industries Served by ECE," pages 70-76.

international institution cannot conduct training and development for everyone in all LDC's. Some principles that will usually be appropriate are:

1. Clearly define the objectives of each training program and limit work to that necessary to achieve the objective. Avoid introducing extra information because it usually detracts from significant completed work. In other words, "teach what one needs to know, not what is nice to know."

2. Formal training and development programs should be built on the "train-the-trainer" concept to promote a multiplier effect from training.

3. Establish priority subjects for training programs based on a "most critical needs" concept.

4. Develop a "package" of training programs using several techniques including: intensive group courses, seminars, self-study programs, simulation, case studies, etc.

5. Training and development programs are successful when LDC's become self-sufficient.

6. In-plant training in a developed country can be very helpful when the plant is similar to one that is to be built in a developing country.

Transfer of Technology

In several sections of this report, the need of developing countries for assistance in selecting and using appropriate technology has been mentioned. Technology in this context is intended to include all fertilizer-related knowledge and skills ranging from exploration for raw materials to application of fertilizers to the soils. Research and development needs have been discussed; obviously new technology will not be effective until it is put into practice. Proper adaptation and application of existing technology are equally important.

International organizations can and should help by:

1. Maintaining centers of information on various types of technology.

2. Establishing databanks of techno-economic information facilitating rapid appraisal of the suitability of alternate technologies under various conditions.

3. Conducting regional and international seminars to inform developing countries about available technology, to exchange information, and to identify areas where further studies are needed.

4. Supplying multidisciplinary teams to assist developing countries in planning a fertilizer production and distribution system that will best meet their needs and make the best use of their resources.

5. Establishing pilot or demonstration facilities to demonstrate the usefulness of production processes, distribution systems, and agricultural practices in typical developing countries.

Improved Data Collection, Processing, Reporting, and Forecasting on World Fertilizer Investment, Production, and Use

An adequate supply of fertilizer at a steady rate with a reasonable price is an essential factor in any program designed to meet increasing global food demand. This implies that ample investments will be made well in advance of need to ensure development of raw materials supplies, plant capacity, and infrastructure to ensure this supply/demand balance is maintained. The destabilizing effects of abrupt changes in the supply and/or price of fertilizer, even for a short period of 1 or 2 years, can cause reverberations throughout the economy of a country and, in certain cases, whole regions of the world.

There is evidence that just this sort of disruption is starting to occur and in definite cycles. Two such cycles have occurred, one in 1965-1972 and we are now in the midst of the second. The 1965-1975 cycle ended just as the global food shortage occurred for the second time in recent history (1964-1965 and 1972-1973). We are now well into our second cycle, having gone past the high fertilizer price stage (1973-1975), and are now faced with the prospects of depressed prices for possibly the next 3-5 years.

The high prices of 1973-1975 markedly affected fertilizer consumption. For the first time since 1945, fertilizer use in 1975 failed to increase over the previous year. Nitrogen consumption remained static at about 38.8 million mt, whereas use of phosphate and potash dropped 5.0% and 3.8%, respectively, from the previous year's level of use. While difficult to prove

because of other interacting factors, this drop in consumption, coupled with the failure to realize the normal annual growth rates of 7%, probably had the effect of farmers producing about 56 million mt less food than would have been the case had such abrupt rises in fertilizer prices not occurred. This is the equivalent of one-half of India's current food consumption.

While the immediate effect of the recent fertilizer shortage was panic buying and high prices due to scare talk of a permanent fertilizer shortage, the long-term effect is more important. This led to policy decisions that resulted in excessive building of inventory and huge investments in fertilizer facilities that will almost surely be underutilized for the next several years. This will almost certainly lead to underinvestment, eventual shortages, and the repeat of the cycle--the next time perhaps with a more telling effect.

It is important that the factors causing these cycles be understood and their effects minimized. One of the most obvious causes is faulty market information or misinterpretation of that which is available. The result has been frequent overstating as often as understating the seriousness of the problem and wrong policy choices (or overreaction) to solve these problems.

No one nation or group of nations can solve this problem. International agencies such as FAO, UNIDO, the World Bank, IFDC, and others should develop policies that will eventually get at the problem. Some of the suggested moves are:

1. Encourage the establishment of a system which will accurately assess the size, quality, and economic potential of global reserves of fertilizer raw materials.

No comprehensive, up-to-date, accessible, and verifiable data exist on key fertilizer raw materials. Using phosphate rock as an example, no database exists on world resource tonnage, ore quality, and the technical and economic potential of each deposit for exploitation. This is partly due to incomplete geologic data and also because of the proprietary nature of the information. There is no standardized system of phosphate classification. There is no consistently clear distinction made between total resources and economic reserves. Therefore, work should be done to classify and characterize deposits in accordance with universal and specific standards mutually agreed upon. Further, the establishment of comprehensive data on total resources, economic reserves, and marketable ores (also in accordance with a universal code) is vitally needed.

Such an endeavor, by its very nature, will be a long-term, continuous effort. It will require international cooperation and constant monitoring. International agencies such as the World Bank, UNIDO, and IFDC should encourage the intensification of this effort. It should be kept up to date as new deposits are discovered and more information about previously known deposits becomes available.

2. Encourage the development or improve methods in demand analysis and forecasting fertilizer use.

While numerous attempts have been made to improve demand analyses and particularly forecasting, most have proven inadequate to describe anything but the most aggregated and mature markets. The present techniques have proven extremely inadequate in forecasting fertilizer use over the short run, in young markets with little historical data, or in situations where major disruptions in the input/output relationship develop. A major effort should be made to improve the accuracy of short- (6-24 months) and long- (5-10 years) run demand analyses and forecasting, particularly in young markets where volatile situations are more likely to occur. This type of work is needed for each of the major nutrients (nitrogen, phosphate, and potassium), and where feasible, major fertilizer products as well. A series of methodologies need to be developed that can effectively predict major shifts in fertilizer use among crops and regions within a country and provide better estimates of the effect this may have on food production. The chance for success of this work is good, but will require a long-term effort.

3. Encourage the improvement of the reliability of data for measuring factors affecting fertilizer demand.

Accepting that the methodology used to estimate fertilizer demand or forecast use is less than adequate, current techniques are hampered even further by the lack of accurate data. This is particularly true in the developing world. Specific emphasis needs to be focused on understanding the importance of accurate fertilizer use benefit:cost ratios, crop budgets, and fertilizer response functions for key agricultural crops, as well as a better understanding of the constraints to adoption of new technology and to increasing fertilizer demand.

4. Develop methodology that will provide reliable forecasts of fertilizer supply.

There are numerous instances where investments in new capacity either do not occur or occur at rates too slow to satisfy

demand. There has also been a nagging problem of underutilized capacity. Little methodology has been perfected to predict either short-term (6-24 months) or long-term (5-15 years) aggregate fertilizer supply capacities. As in the case for demand, reliable forecasts for supply cannot be developed without reliable data. An essential area of research is in identifying the relevant factors that determine aggregate supply. Such a methodology should have equal application to local, national, regional, and global situations.

5. Encourage the development of a system that will assist policymakers in making the most effective use of raw materials, capital, facilities, and personnel in supplying fertilizer to the farmer.

The ultimate solution to reducing the cyclical nature of fertilizer consumption and production is the establishment of a system that can successfully integrate various factors determining supply and demand for fertilizer. Such a system must be able to present feasible and applicable alternatives that can be understood by the decisionmakers. Specifically, the system should be able to transmit data rapidly to key information points; and assess efficiency alternatives in the use of raw materials, capital, plant investment, transport and storage systems, and personnel required to produce, market, or use fertilizer. Such information should be factual, comprehensive, and readily available. Further, it must be presented so policymakers can accurately interpret the information.

This will no doubt require the establishment of a comprehensive network involving key fertilizer-producing and consuming areas and integrating the information in the ways to ensure that it will be quickly and accurately used.

International agencies should gear their policies to ensure that such a system is established. This effort will be costly, long-term, and difficult to implement. However, the payoff from such an effort is great in terms of the potential costs and consequences of not doing this work.

Loans and Grants From International Agencies

Numerous sections of this report deal with recommendations on what should be done to ensure that adequate supplies of fertilizer are available to produce the needed food between 1975 and the year

2000. Most of these recommendations will involve substantial quantities of money if they are to be implemented. While many, perhaps most, of these could be financed by individual governments, several activities, some perhaps key to achieving overall food production targets, cannot or will not be financed by national governments. Many of these activities can be initiated by international institutions through selective use of grants and/or loans.

The choices in deciding whether to make these loans or grants will not be easy, for all too often there are more worthy projects to support than funds available to cover them. These choices on fertilizers should be made in accordance with certain broad policies. Some of those that might be considered follow.

Private Capital Policy

In all but the centrally planned countries, private capital investments, either foreign or domestic, are the dominant sources of funding in national development. Government policy in most of these countries is designed to ensure that private money is attracted to support development needs.

Most international agencies are set up to work with and/or through government bodies. Only a very limited number work either directly or indirectly with the private sector. Because of this arrangement, there is always a possibility that projects that could have been financed by private capital, particularly from foreign sources, end up being funded by international agencies, and subsequently are government owned. This then sets a pattern that leads to an entire industry being state owned even though that may not have been the intent of the government or the lending agency involved. There are numerous cases where this has happened in the fertilizer industry. The net result has been a declining use of foreign capital and an increasing demand for financial support from international agencies already short of development funds. This is unfortunate inasmuch as such moves slow, rather than speed, the development of key sectors of a country's economy.

Each international agency must establish a clear policy as to the role it feels private capital (foreign or domestic) should play in a project, and then take measures to ensure that such a policy is enforced within that agency. Frequently, this is done by clearly stating that no funds can be used for an activity where evidence exists that private capital is available and willing to get involved.

In cases where private capital (foreign or domestic) is available but unwilling to invest because of political uncertainties, an agency may have to provide guarantees to ensure the security of the investment. Establishment of a clear-cut policy in the above area is needed, otherwise insufficient funds are likely to be available for building all of the fertilizer plants and infrastructure needed by the year 2000.

Technology Transfer Policy

Many developing countries want the most modern technology available based upon the belief that this will speed economic development and close the great gap between their economies and those of the developed nations of the world. There is evidence that such moves frequently fall short of their intended goals. This is because such projects are frequently capital- rather than labor-intensive. They contribute to, rather than help solve, the nation's employment problems.

In addition, many of these projects fail to transfer the intended benefits to the farmer. This may be due to lack of proper infrastructure to support such a facility, inability of the economy to absorb the output, or lack of competent personnel to operate the plant. The net result is that the units operate below design capacity and hence an inordinately large percentage of the production cost of the unit consists of capital-related charges.

International agencies should consider establishing a policy of financing only those projects where the infrastructure will support the technology and where the benefits to the overall economy offset any potential disadvantages to the labor force. This means international agencies should consider intensification of financing the less glamorous projects such as low-technology (rock phosphate for direct application, small fertilizer plants, small farmer programs, etc.), labor-intensive projects. Such activities are usually low users of funds, difficult to administer, and often unpopular with local governments.

Ideally, international agencies should consider the degree of development in each country and offer projects of a technological level their economy may absorb. In some cases, the technology is labor-intensive or unsophisticated but quite adequate. There is little evidence to suggest that such changes are now occurring. Clearly, these agencies need to set a policy related to technology transfer and define it in research, lending, and manpower development terms.

Self-Sufficiency and Regional Trade Policy

Many countries are following a nationalistic policy of becoming self-sufficient in food and fertilizer production at almost any cost because they deem it essential for the stability of the country. In many cases the costs of such moves are completely out of proportion to the benefits that are likely to arise. There is evidence that regional cooperation dealing with the sharing of resources may be a more logical step in the development process.

International agencies providing loans or grants need to consider fostering activities that encourage regional cooperation and avoid funding national projects that are much less economical than some regional mode of cooperation.

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