PN-ABD-287
62760

Fertilizer Production and Supply Constraints and Options in Sub-Saharan Africa

International Fertilizer Development Center

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by

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May 1989

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Library of Congress Cataloging-in-Publication Data

Schultz, J. J., 1936-
Fertilizer production and supply constraints and options in sub-Saharan Africa / by J. J. Schultz and D. H. Parish.
p. cm.--(Paper series ; P-10)
"May 1989."
Includes bibliographical references.
ISBN 0-88090-075-X : $4.00
1. Fertilizer industry--Africa, Sub-Saharan. I. Parish, D. H. (Dennis H.), 1926- . II. International Fertilizer Development Center. III. Title. IV. Series: Paper series (International Fertilizer Development Center) ; IFDC—P-10.
HD9483.A4372S38 1990
338.4'766862'0967--dc20 89-15559
CIP

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IFDC publications are listed in *Publications of the International Fertilizer Development Center,* General Publication IFDC—G-1, which is available free of charge.

Fertilizer Production and Supply Constraints and Options in Sub-Saharan Africa

Summary

Sub-Saharan Africa accounts for about 9% of the world's population but uses less than 1% of the world's fertilizer (*1, 2*). The population growth rate, at about 3% annually, is among the world's highest. Overall, growth in fertilizer consumption has been quite slow and erratic due to a number of technical, economic, and policy constraints. On the other hand, a very steady growth in fertilizer consumption has occurred in those export- and import-substitution crop sectors that historically have enjoyed the benefits of a sound management and technical infrastructure with a strong emphasis on fiscal responsibility. Unfortunately, it is often difficult to emulate such sound, integrated, and autonomous management characteristics in a government setting where many different agencies are charged with separate aspects of agricultural sector development.

In a setting of relatively low and unstable demand due to the lack of the necessary supportive government and pricing policies, the decision to invest in local production facilities should be approached with a great deal of caution. The continuing need for foreign exchange, not only to recover the investment but also to purchase raw materials and other inputs required to sustain cost-effective production, must be appreciated. The combination of high-cost production units and modest or erratic markets in many sub-Saharan countries should preclude heavy investments in local production units. This situation then favors a strong examination of the feasibility of joint ventures and other cooperative agreements designed to result in cost-effective and secure supplies of fertilizers.

In both the short and long term, improved efficiency in fertilizer production, supply, and distribution in sub-Saharan Africa seems to be heavily dependent upon the degree of stability, management skill, and financial autonomy and responsibility that is developed and effectively deployed throughout the agricultural sector.

Introduction

Because fertilizers are bulky, variable in composition and quality, and perceived to have a relatively low value, their supply and use create problems not associated with many other products of industry. Delivery of the correct fertilizer to the farmer when and where he needs it requires a heavy investment in production and supply units, distribution and storage facilities, and finally, sales and farmer service.

An upset in any of these items leads to heavy financial costs both to the system and to the farmer and therefore ultimately to the nation. In many cases attempting to provide the farmers with an ample supply of low-cost fertilizer can result in just as serious a drain on national wealth as can a lack of fertilizers.

This paper draws attention first to those key items that tend to constrain development of fertilizer production units and alternative supply systems in sub-Saharan Africa. Then follows a broad review of the available fertilizer production and supply options and a discussion of the possible role and shortcomings of the various options in meeting national fertilizer needs in specific situations.

Stability and Continuity of Demand

The viability of any fertilizer supply system, be it based on local production or imports, depends heavily upon a reasonable level of stability with regard to continuity of demand and profitability. A discussion of the critical role of stability with respect to demand and institutional priority on the development of efficient fertilizer production/supply units follows.

Need Versus Demand

The low level of actual demand for fertilizer in many sub-Saharan countries severely restricts the level of investment that can be made in local production units. Establishing a need for fertilizer is quite academic unless it can be translated into actual demand in the marketplace. Although agronomists worldwide have done a commendable job in establishing technologically sound crop response data, more than agronomic knowledge is needed to bring about the routine use of fertilizer. Most fertilizer sector studies describe an urgent need for increased applications of fertilizers, and many project an optimistic but seldom realized demand based on the premises of improved agricultural practices, population growth, improved nutritional standards, and favorable institutional support. The current status of sub-Saharan Africa, which represents approximately 9% of the world's population yet uses only about 1% of the world's fertilizer, is well known. However, this poor performance in actual use is greatly at odds with projected fertilizer needs. Some examples of projected demand for fertilizer, compared with achieved performance in selected African countries, are shown in Figure 1. Nigeria, the exception of the countries shown in Figure 1, used oil money to stimulate fertilizer demand.

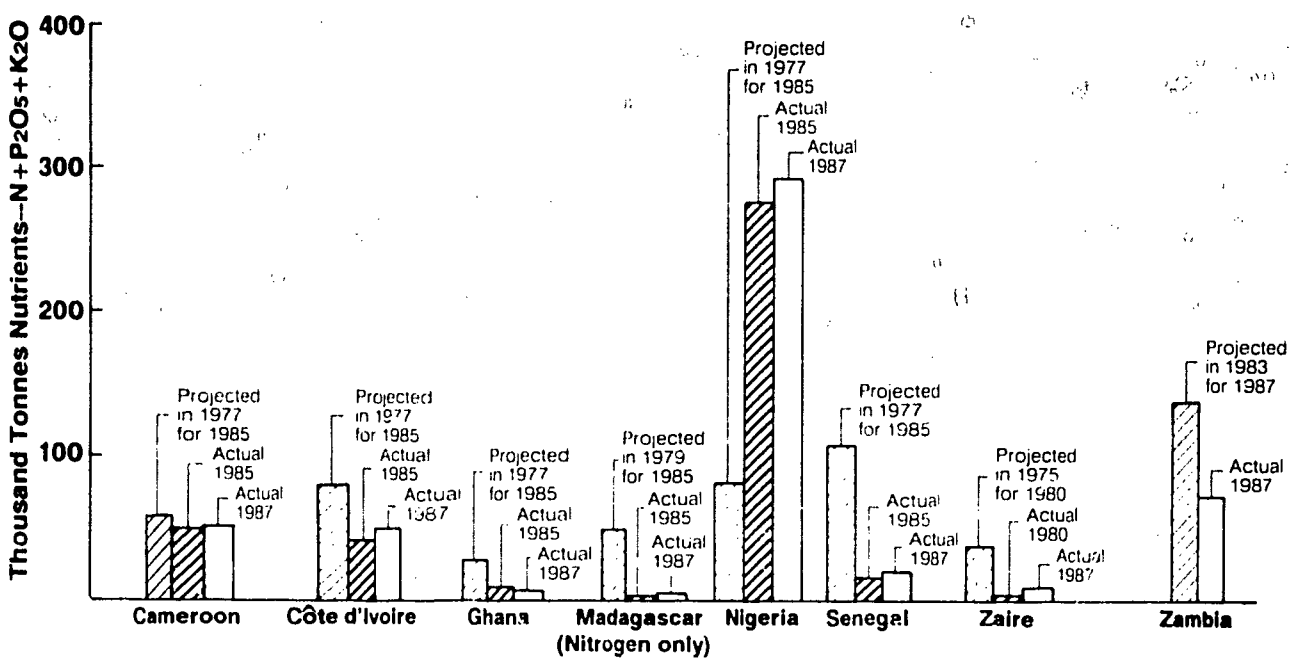

Figure 1. Examples of Projected Fertilizer Demand Compared With Actual Consumption for Selected Sub-Saharan Countries, Projections (*3,4,5,6*); Actual Consumption (*2*).

Product Selection and Availability

Fertilizers are often regarded as a relatively low technology input, but in fact their use is generally only profitable when combined with higher technology in the form of improved seeds and good agronomic production practices. There are, of course, exceptions. For example, Nigerians use much fertilizer on unimproved varieties of sorghum and millet; in this case, however, the fertilizer used is heavily subsidized.

The farmer uses fertilizer to make a profit, and therefore only where there is an ensured market for his extra produce will he take the risk of investing heavily in fertilizer. To minimize his risk and maximize his profit, the farmer needs a reliable and timely supply of fertilizers in quantities that are cost effective for his needs. The agronomists decide what levels of nutrients (N, P, K, and others) are needed and when and how to apply. Generally, this information is sufficient for the needs of the farmer. However, when it comes to deciding in what forms the needed nutrients shall be supplied to the farmer, the agronomist is often preempted by the economies of scale of modern fertilizer production units and the major reductions in distribution and storage costs achievable through the use of high-analysis fertilizers. Thus, less concentrated single superphosphate (SSP), ammonium sulfate (AS), and calcium ammonium nitrate (CAN)—all excellent and easily used fertilizers—are replaced by more concentrated products such as diammonium phosphate (DAP) and urea, both of which must be carefully applied if their efficiency of use is not to be reduced. The incorrect use of high-analysis fertilizers can lead to very disappointing results.

An additional complication facing the fertilizer sector in sub-Saharan Africa is that individual agronomists, as a result of their field work, often develop quite complex fertilizer recommendations that are difficult to supply in a cost-effective way. Bulk-blended fertilizers, although attractive in supposedly offering fertilizer formulations tailored to farmer needs, may create more problems than they can solve for most countries in sub-Saharan Africa. The availability of single-nutrient fertilizers or one or two well-selected multinutrient fertilizers supplemented with a straight source of nitrogen such as urea can play a key role over large areas of sub-Saharan Africa where simple fertilizer practices are all that is needed.

Demand Forecasting

The foundation of any fertilizer production/supply scheme is reliable demand forecasting that translates government-planned demand into actual or effective demand. Good fertilizer demand forecasting needs a multidisciplinary approach, including a strong market research component. In developing countries, this latter component is most often the weakest link in the chain of demand forecasting activities, which should begin with the farmer and move upward to the national procurement agencies or production units.

Demand projections in many developing countries are made by the government research and extension staff who often have little interest in either the delivered cost of fertilizer or the profitability of fertilizer use. This lack of interest in the financial aspects of fertilizer-related decisions leads to a string of serious faults and is a good reason why the wholesale, and most definitely the retail, trade in fertilizers should be taken out of the hands of those government agencies where financial responsibility may be lacking.

The favorable possible impact of good forecasting and planning on the landed cost of fertilizer in Cameroon, for example, is shown in Table 1. This table illustrates the saving (about US $35/tonne) that can be expected in procurement alone, primarily because of more favorable f.o.b. prices and ocean freight rates resulting from a well-managed procurement system. Sound demand forecasting, of course, is the key element needed to develop such effective procurement, storage, and movement plans to ensure timely delivery of fertilizer to the farmer. Some of the Government-authorized fertilizer importers in Cameroon have exceeded these savings by importing bulk material and bagging it at the port using leased bagging machinery. In one such operation in 1985 ammonium sulfate was imported and bagged locally accruing a savings of about US $50/tonne when compared with the cost of the Government-operated system.

Table 1. Estimated Landed Costs and Savings Due to Improved Management of Fertilizer Procurement in Cameroon (7).

Fertilizer Material	Landed Cost[a]		
	Current System	Improved System	Savings[b]
	(US $/tonne)		
Ammonium sulfate, 21% N	226	190	36
Urea, 46% N	283	234	49
Diammonium phosphate, 18% N, 46% P_2O_5	335	301	34
Potassium chloride, 60% K_2O	230	194	36
20-10-10 Compound	281	245	36
15-15-15 6S-1B_2O_3 Compound	293	256	37

a. Includes f.o.b. cost of fertilizer in 50-kg bags, ocean freight, all port charges, and movement to storage facility adjacent to port.
b. Saving due primarily to consolidation of orders resulting in lower f.o.b. prices, lower ocean freight rates, and lower handling costs.

Procurement Policies and Value of Timing

In theory, large centralized procurement of most commodities, including fertilizer, should be beneficial because large standardized orders can result in good value. However, as indicated above, problems often arise if government officials are charged with the task of fertilizer procurement in an environment lacking in both overall knowledge of the total marketing system and the ability to integrate all of its components, including financial

accountability. The main problem arises from the fact that the value of fertilizer is heavily dependent upon timing. A fertilizer of good quality and potentially high value quickly becomes a liability if it does not arrive at the farm in time for optimal use. If it arrives too late, it may be wasted through inefficient use or, if it is stored for the next planting season, it may deteriorate and lose value in addition to accruing excessive storage costs. The smooth operation of the fertilizer delivery component of the overall fertilizer supply and marketing system is heavily dependent upon an acute awareness of the value of correct timing.

Priority Given to Fertilizer

The low perceived status of fertilizers is often both the cause and the result of the low priority given to its supply and use. Insufficient research and education in the use of fertilizer on the one hand, together with ineffective government policies relative to fertilizer use, pricing, and crop production plans on the other, adversely affect the priority given to the allocation of foreign exchange and other institutional support needed for the reliable and cost-effective supply and use of fertilizer.

Cost:Price Ratios—Farming, which here means selling farm produce for cash, is subjected to innumerable variables, including natural disasters; therefore, it is essential that a reasonably stable environment be established with regard to the economics of fertilizer use if one expects a fertilizer supply system to work at an acceptable level of efficiency.

Figure 2 provides examples of the often-observed wide fluctuations in fertilizer use attributed almost entirely to lack of stability in the economics of fertilizer use. Such wide and often unpredictable fluctuations in demand brought about by a host of economic factors make it nearly impossible to develop and operate a cost-effective fertilizer supply system on a continuing basis. This constraint, lack of policy and pricing stability, often heads the list of constraints to fertilizer use, and therefore to fertilizer supply, in sub-Saharan Africa.

Foreign Exchange—The countries of sub-Saharan Africa have essentially agricultural-based economies and rely heavily on imported industrial products. This means that the availability of foreign exchange is a vital component in their development planning. The debt service (the amount of export earnings, expressed in percent, needed to service the country's outstanding debt) of many African countries is very high and thus severely restricts available foreign exchange that can be allocated for fertilizer imports or for investments in domestic production facilities. Unless the debt service burden is decreased to a manageable proportion (about 20%), there is little hope for bringing about the economic conditions needed for steady growth of an intensive agriculture sector, the main prerequisite for the economic operation of fertilizer production/supply units. An example of the debt service burden for selected African countries is shown in Table 2.

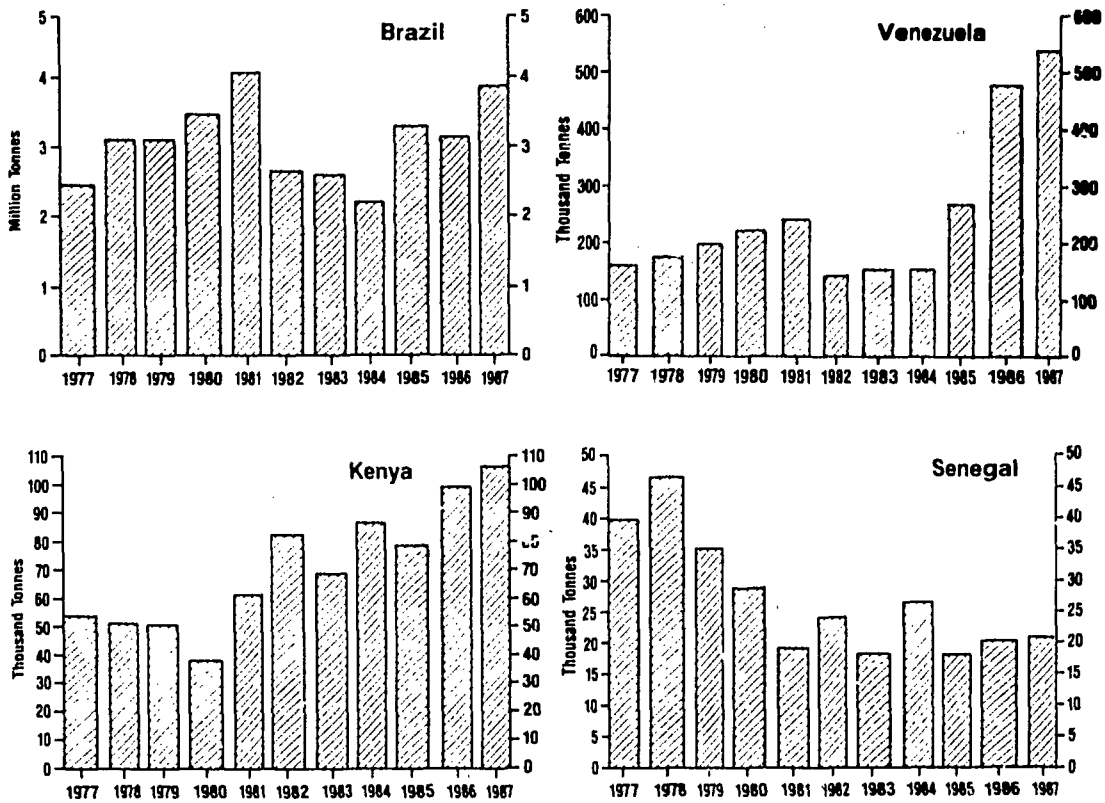

Figure 2. Trends in Fertilizer (Nutrient) Consumption in Selected Countries—Total $N+P_2O_5+K_2O$ (2).

Table 2. Debt Service for Selected Countries, 1986[a] (9).

Country	Outstanding Long-Term External Debt	Debt Service, 1986
	(million US $)	(%)
Burkina Faso	616	14.8
Cameroon	2,772	22.8
Ghana	1,413	10.8
Madagascar	2,635	27.7
Malawi	910	40.1
Niger	1,251	40.3
Nigeria	21,876	23.4
Senegal	2,471	20.2
Somalia	1,415	62.1
Togo	882	32.5

a. Debt repayment (principal plus interest) expressed as a percentage of income earned from export of goods and services in year specified.

Export- or import-substitution crops such as cotton have proved to be more stable markets for fertilizer than have other crops, as shown in Figure 3. However, even in the cotton sector, which is characterized by adequate national-level technical and management knowledge and timely availability of foreign exchange resources, recent declines in world cotton prices have caused serious problems.

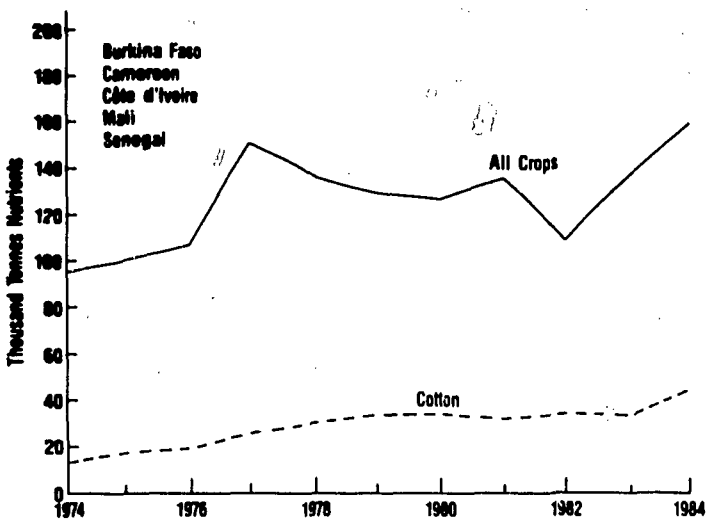

Figure 3. Trends in Nutrient ($N+P_2O_5+K_2O$) Consumption in Cotton Sub-Sector Compared With Total Sector in Selected Sub-Saharan Countries (9).

The Role of Fertilizer Distribution

The smooth and efficient operation of most fertilizer production/supply units depends heavily upon a well-functioning distribution system. This is especially true in many of the countries of sub-Saharan Africa, which are characterized by congested port facilities, extremely tight seasonal demand patterns, and the need to transport the fertilizer over long distances to inland farming areas. Therefore, it is essential that decisions regarding production/supply be closely linked with those involving distribution.

Priority Given to Fertilizer Movement

The failure to view fertilizer as an "essential commodity" with a high value to the farmer, and ultimately the country, is often the most severe constraint to effective distribution and use of fertilizer in many countries, including those of sub-Saharan Africa. This, in turn, adversely affects the production/supply unit.

Fertilizer is a bulky product with a variable storage life; significant knowledge and skill are required for its manufacture, packaging, transportation, handling, storage, and use to ensure effective economic returns at all levels. Its movement from the factory or port to the farm must often be integrated with the movement of a large number of competing products (for example, grain, fuel, and cement) as well as a number of export commodities, such as lumber, cotton, coffee, and cocoa, bound for the port.

As illustrated in Table 3, the tonnage of fertilizer moved in sub-Saharan Africa is usually quite small compared with the tonnage of other commodities commonly perceived to be more essential, such as grain and cement. Because of the smaller tonnage of fertilizer, together with its relatively low perceived value and specialized use, little or no priority may be given to its movement and use. This lack of priority leads to (1) delays in berthing of fertilizer cargos, (2) labor disputes relative to handling fertilizer cargos, (3) ineffective transport planning, (4) unfavorable transport rates, and (5) wasteful handling, storage, and use practices.

Table 3. Comparison of Annual Fertilizer Tonnage With Annual Imports of Cement and Cereal Grains for Selected West African Countries (9).

Country	Fertilizer Consumption[a]	Imports: Cement[b]	Imports: Cereal Grains[c]
	(tonnes/year x 1,000)		
Burkina Faso	20	112	89
Cameroon	120	293	121
Côte d'Ivoire	100	972	545
Ghana	25	68	311
Guinea	3	·	186
Mali	50	19	367
Niger	4	77	45
Nigeria	625	4,827	2,350
Senegal	80	375	698
TOTAL	1,027	6,743	4,712

a. Estimated product tonnes based on FAO nutrient data, fiscal year 1984/85.
b. United Nations International Trade Statistics Yearbook (1985); values are for 1980 except Côte d'Ivoire (1981), Mali (1979), and Nigeria (1977).
c. FAO Trade Yearbook (1984, Vol. 38); values for 1984.

It may be true that many sub-Saharan countries lack certain desirable infrastructural and physical facilities for the handling and storage of fertilizer, and the overland transport distances are certainly great, as illustrated in Figure 4. However, the difficulties caused by the lack of certain facilities should not be overemphasized. Almost without exception throughout sub-Saharan Africa, adequate facilities are available for the efficient supply and distribution of fertilizer if, and only if, the system is properly planned and managed and the appropriate priority is given to fertilizer. The truth of this statement is illustrated by observing the smooth and efficient movement of many other essential commodities in the most remote regions of Africa. Wheat flour, lumber, fuel, cement, and construction materials are generally available at all levels down to the smallest and most remote village. Fertilizer, too, if perceived to be essential and valuable to the user, will find its way to the most remote village. The establishment of this "essential commodity" concept at all levels, from the highest level of government policymakers to the consumer, is the key to the effective use of the existing infrastructure and related physical facilities. This discrepancy in priorities is clearly shown in Table 3. In the nine West African countries selected for comparison, nearly 5 million tonnes of grain and 7 million tonnes of cement were imported, processed, and distributed annually. During the same period, total fertilizer consumption (basically imported material) amounted to only about 1 million tonnes of product of which about 60% was in Nigeria alone. It is true that fertilizer has to be moved out into the rural areas, whereas cereals and cement are consumed mainly in the large urban areas; nevertheless, given the appropriate incentives, many of the principles used to efficiently deliver cereals and cement to a large number of consumers could be applied to fertilizer.

Technical and Managerial Resources

Various estimates indicate the need for a substantial increase in the number of qualified personnel to bring about and sustain growth in the fertilizer sector of sub-Saharan Africa. In one projection (Table 4) a need for about 32,000 additional workers is indicated in the 20-year period 1982-2002 (*10*). This is equivalent to less than 0.01% of the current population of sub-Saharan Africa, which numbers about 450 million; however, in terms of skilled population the percentage is, of course, much greater.

These data indicate that about half of these new workers will be needed in production while the remainder will be evenly divided between marketing and use. These projections may be on the high side in that they assume a rather high growth rate in fertilizer consumption (3.5 million tonnes of nutrients in 2002 compared with about 1.3 million tonnes today). The point is clear, however, that the lack of trained personnel could, indeed, constrain the production sector even though the number of people needed is small when compared with the total population.

Figure 4. Area Within 500 km of African Ports.

Table 4. Additional Personnel Requirements Projected for Fertilizer Sector in Sub-Saharan Africa (*10*).

	Personnel Requirements		
Activity	1982-1992	1992-2002	1982-2002
Fertilizer production	7,092	8,825	15,917
Fertilizer marketing	3,546	4,413	7,959
Fertilizer use	3,546	4,412	7,958
TOTAL	14,184	17,650	31,834

It is important to observe, however, that throughout the developing world numerous industrial enterprises such as mining, cement, light manufacturing, refining, brewing, lumber and building products, and food processing thrive despite the statistical evidence that indicates low literacy levels and lack of educational opportunities for developing qualified industrial workers. Many of these industries are much like fertilizer manufacturing and require the same basic type of management, technical, and operating skills. The fertilizer production sector, too, can thrive despite the often projected shortage of personnel if, and only if, the entire sector (production, marketing, and use) is given the priority needed to ensure the development and allocation of qualified personnel.

It is also encouraging to note that many areas in the fertilizer production/supply sector require skills that are easily obtained through on-the-job training. For example, a typical phosphate fertilizer production unit

(DAP/TSP/NPK) in a developing country may have a total workforce of about 300-500 employees depending upon a number of local factors. Of these employees, less than 25% will be in management and technical/supervisory positions requiring university or industry-specific specialized training. The remainder will be operators, maintenance workers, laborers, and support personnel who can, and should, gain their required skills on the job. Likewise, the simpler fertilizer bagging or blending plants may require only a handful of skilled and semiskilled managers and technicians.

Although the number of people needed in the production sector is quite small, the most urgent need for human resources in sub-Saharan Africa seems to be in the development of increased management awareness and skills especially as they pertain to (1) planning and scheduling, (2) integration of production/supply with fertilizer marketing and use, (3) cost control, (4) production efficiency and quality control, and (5) training of personnel to obtain added depth and skills within the organization. A greater delegation of responsibility for day-to-day decisions in terms of both management and finance is needed to maximize the value of trained staff.

Local Production Versus Imports

Despite the foregoing constraints to fertilizer use, one must still move ahead and formulate some type of supply scheme. In this regard the following factors should be considered in the development of a practical, flexible, and cost-effective fertilizer production/supply system.

Raw Material Resources

Very seldom does a country possess all of the raw material resources needed to produce fertilizer. A country with abundant phosphate resources usually does not have sulfur or other acid sources needed to solubilize the phosphate; likewise, a country with natural gas resources for ammonia and urea production may not have the other nutrient materials needed to produce a balanced fertilizer. As a result, most countries are quite heavily dependent upon importation of some raw or intermediate materials even if they have a strong local production base for a given nutrient.

Furthermore, the argument of security of supply as a justification for local production often has little relevance because, as previously indicated and discussed in more detail later, most local production units are still quite heavily dependent upon importation of some raw or intermediate materials as well as critical machinery and equipment repair and replacement items. All of these items require substantial and steadily recurring allocations of foreign exchange in order to maintain a high level of efficiency. This is especially true in the case of phosphate and NPK production units, which usually depend heavily upon the importation of sulfur or phosphoric acid and potash.

Capital Investment and Production Costs

Fertilizer production units are relatively expensive, and to remain economic they must operate at high capacity utilization with favorable pricing. Typical investment data for a number of fertilizer production/supply units are shown in Table 5. These costs assume a grass roots facility in a typical developing-country coastal location. Experience has shown that the actual investment costs could easily be twice what is expected depending upon a number of site-specific conditions, especially the time required to complete the project, government regulations regarding importation of equipment, taxes, and the level of required infrastructure and related facilities (*13*).

The estimated factory-gate production cost for a number of products is shown in Table 6, and an example of the typical factory-gate and farm-gate cost per tonne of nutrient (P_2O_5) from several phosphate production units is shown in Figure 5. In this example (Figure 5) the indicated cost of P_2O_5 is a net value after taking credit for any nitrogen or sulfur contained in the product. The nitrogen was valued at US $359/tonne, and sulfur was valued at US $135/tonne. Examples of the effect of capacity utilization on production cost in a number of relatively small NPK production units and in a small and a world-scale urea production unit are shown in Figures 6 and 7, respectively. These costs, of course, are for illustrative purposes and will vary considerably depending upon the site-specific cost structure.

These data show quite clearly that before entering into an investment in local production facilities one must very carefully examine the cost:price structure of local production compared with imports in the context of (1) fluctuations in demand (product type and quantity) and its impact on capacity utilization, (2) availability to meet the recurring demand for foreign exchange to support steady operation of a local produciton unit, (3) a favorable factory-gate pricing policy, and (4) the ratio of local versus foreign currency costs in the overall production cost equation.

It is interesting to note in Table 6 that in new plants the fixed cost of production, primarily composed of capital charges (repayment of borrowed money with interest), often represents more than one-third of the factory-gate production cost. This is especially true for nitrogen production units where the fixed cost of production in a small plant may exceed 80% of the total; in phosphate fertilizer production units, the level of fixed cost, primarily capital charges, is highly dependent upon the process, as is shown in Table 6. For all production units, however, a high-capacity utilization is essential to minimize the fixed cost burden; this is shown in Figures 6 and 7.

Table 5. Estimated Capital Investment for Various Fertilizer Production Units—New Facilities in Developing Country Location.[a]

Production Unit	Raw Material Source	Capital Investment		
		Fixed	Working[b]	Total
		(million US $)		
Nitrogen				
Ammonia/urea—small plant (280 tpd urea–128 tpd N)	Domestic	149.0	9.0	158.0
Ammonia/urea—large plant (1,650 tpd urea–759 tpd N)	Domestic	392.0	28.0	420.0
Phosphate				
Direct application phosphate rock 0-30-0 (100 tpd P_2O_5)	Domestic	6.6	2.3	8.9
Granular single superphosphate 0-20-0 (100 tpd P_2O_5)	Domestic P, Imported S	28.2	4.4	32.6
Granular sulfuric acid-based partially acidulated phosphate rock 0-22-0 (100 tpd P_2O_5 at 50% acidulation level)	Domestic P, Imported S	26.0	4.0	30.0
Granular triple superphosphate 0-46-0 (500 tpd P_2O_5)	Domestic P, Imported S	180.0	22.0	202.0
Diammonium phosphate 18-46-0 (500 tpd P_2O_5 and 195 tpd N)	Domestic P, Imported S and NH_3	204.0	26.0	230.0
Nitrophosphate (Odda process) 20-20-0 + 26-0-0 (500 tpd P_2O_5 and 955 tpd N)	Domestic	493.0	40.0	533.0
Phosphonitric (mixed acid) 20-20-0 (500 tpd P_2O_5 and 500 tpd N)	Domestic P (Rock) and NH_3, Imported H_3PO_4	262.0	30.0	292.0
Mixed (NPK) Fertilizer				
Dockside bagging unit (800 tpd)[c]	Imported	0.25	0.0	0.25
Bagging plant (800 tpd)[d]	Imported	1.8	1.0	2.8
Bulk blending (500 tpd NPK)	Imported	3.2	4.0	7.2
Compaction/granulation (500 tpd NPK)	Imported	8.7	3.5	12.2
Steam granulation (500 tpd NPK)	Imported	10.4	3.5	13.9
Chemical granulation (500 tpd NPK)	Imported	16.4	3.8	20.2

a. Estimates derived from reported data, mid-1988 basis (*7,11,12*).
b. The working capital requirement may vary quite widely depending upon local demand (offtake) patterns and other site-specific logistical and marketing factors.
c. Capital investment could vary significantly depending upon purchase/lease agreement for bagging machinery and amount of required bagged product storage.
d. Based on 800-tpd ship discharge rate and 5,000 tonnes bulk or bagged product storage.

Figure 7 also strikingly shows that the cost of natural gas has a fairly minor impact on the final cost of production of urea in a new facility.

The usually high investment requirements for exploiting phosphate deposits tend to inhibit the development of indigenous mineral deposits, especially in sub-Saharan Africa where the size and quality of the current noncommercial deposits and the national demand for fertilizer are often small and erratic. Furthermore, with both the phosphate and the NPK production units, there is a continuing need for foreign exchange to finance the cost of imported raw and intermediate materials to sustain production. Even though an ammonia/urea plant is costly to construct, it usually offers a more favorable long-term opportunity to recover these costs provided, of course, the plant is based on an indigenous source of fuel and feedstock.

Farm-Gate Pricing

In addition to a favorable factory-gate pricing structure for a local production unit, it is even more important to select the fertilizer supply alternative (local production, importation, or a mixture of the two) that will result in the lowest cost for the nutrients (not products) delivered to the farm gate. For example, it is not valid to compare the cost of local production of SSP containing 18% available P_2O_5 with the cost of imported TSP containing 46% available P_2O_5 unless this comparison is carried all the way to the farm gate on a nutrient basis. Of course, in this example, if there is a need for agronomic sulfur and if this sulfur is actually paid for, then the combined value of P_2O_5 and S should be considered in the case of SSP.

Because of the importance of farm-gate nutrient cost and the usual need for long-distance transport, both ocean and land, most systems clearly favor concentrated (high-analysis) materials. These materials, though, require a higher level of investment to produce; therefore, to be economical, they demand large-scale, single-product production units operated at a high capacity utilization. Unfortunately, these capital-intensive, high-capacity, and inflexible units are not well suited to the rather modest needs of most sub-Saharan countries.

Scale of Operation

In addition to the above raw material, investment, and pricing factors, the expected scale of operation must also be carefully considered when developing a fertilizer supply scheme involving importation and/or local production.

The key factor in formulating a fertilizer supply strategy is knowing the expected scale of operation (annual tonnage) required now and in the future. This, of course,

Table 6. Estimated Production Cost for Selected Fertilizer Products—New Facilities in Developing-Country Location.[a]

Production Unit	Fixed	Factory-Gate Production Cost: Variable: Raw Materials	Variable: Other	Total
		(US $/tonne bagged product)		
Nitrogen				
Urea—small plant	407	44	16	467
(280 tpd urea–128 tpd N)	(87%)[b]	(9%)	(4%)	
Urea—large plant	180	41	16	237
(1,650 tpd urea–759 tpd N)	(76%)	(17%)	(7%)	
Phosphate				
Direct application phosphate rock	19	62	16	97
(335 tpd product–100 tpd P_2O_5)	(20%)	(64%)	(16%)	
Granular single superphosphate	43	57	29	129
(500 tpd product–100 tpd P_2O_5)	(33%)	(44%)	(23%)	
Granular sulfuric acid-based PAPR	44	56	29	129
(455 tpd product–100 tpd P_2O_5)	(34%)	(43%)	(23%)	
Granular triple superphosphate	113	139	27	279
(1,100 tpd product–500 tpd P_2O_5)	(41%)	(50%)	(9%)	
Diammonium phosphate	128	193	20	341
(1,100 tpd product–500 tpd P_2O_5, 195 tpd N)	(38%)	(57%)	(5%)	
Nitrophosphate (Odda process)	124	75	15	214[c]
(2,500 tpd 20-20-0 product and 1,750 tpd CAN 26-0-0–500 tpd P_2O_5, 955 tpd N)	(58%)	(35%)	(7%)	
Phosphonitric (mixed acid)	69	79	16	164
(2,500 tpd product–500 tpd P_2O_5, 500 tpd N)	(42%)	(48%)	(10%)	
Mixed (NPK) Fertilizer				
Dockside bagging (800 tpd)	4	160[d]	13	177
	(2%)	(90%)	(8%)	
Bagging plant (800 tpd)	7	160[d]	14	181
	(4%)	(88%)	(8%)	
Bulk blended NPK	8	139	12	159
(500 tpd 15-15-15)	(5%)	(87%)	(8%)	
Compaction/granulation	21	127	14	162
(500 tpd 15-15-15)	(13%)	(78%)	(9%)	
Steam granulation	25	127	15	167
(500 tpd 15-15-15)	(15%)	(76%)	(9%)	
Chemical granulation	36	129	16	181
(500 tpd 15-15-15)	(20%)	(71%)	(9%)	

a. Estimates derived from reported data, mid-1988 basis (*7,11,12*). Refer to Table 5 for capital investment estimates.
b. Values in parentheses indicate percent of total factory-gate production cost.
c. Cost per tonne 20-20-0 may be as low as about US $150 per tonne after taking credit for coproduct CAN 26-0-0.
d. Typical for 15-15-15 including US $30/tonne for ocean freight (mid-1987 basis for comparison with other 15-15-15 supply alternatives)

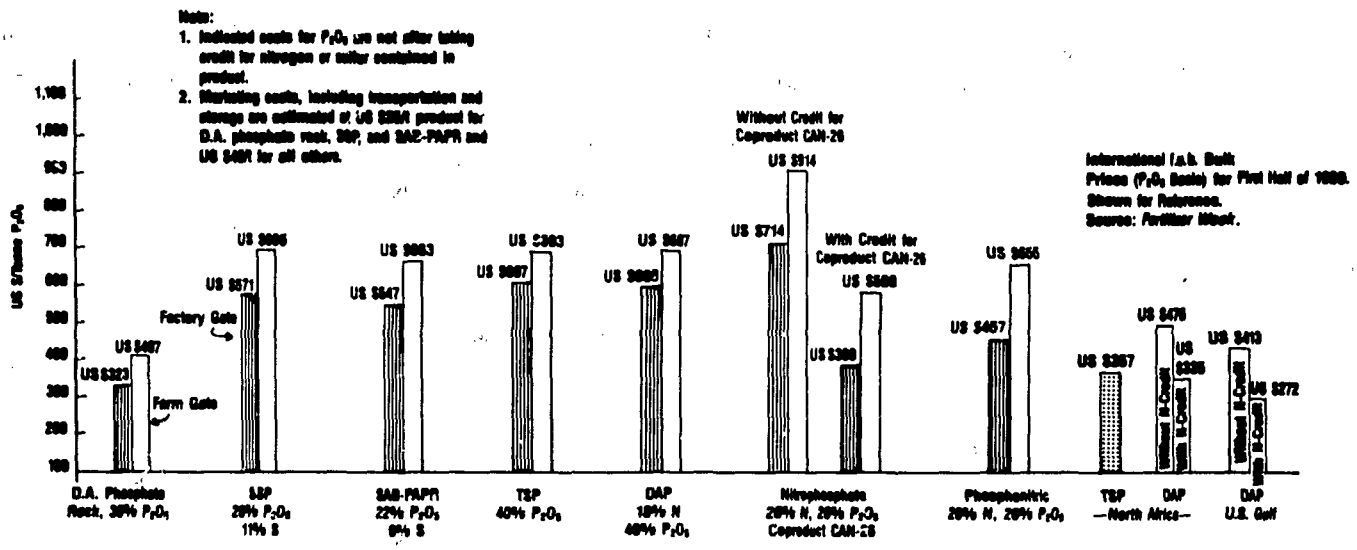

Figure 5. Estimated Factory- and Farm-Gate Cost of Phosphate (P_2O_5) Fertilizer From Various Sources—New Facility (*11*).

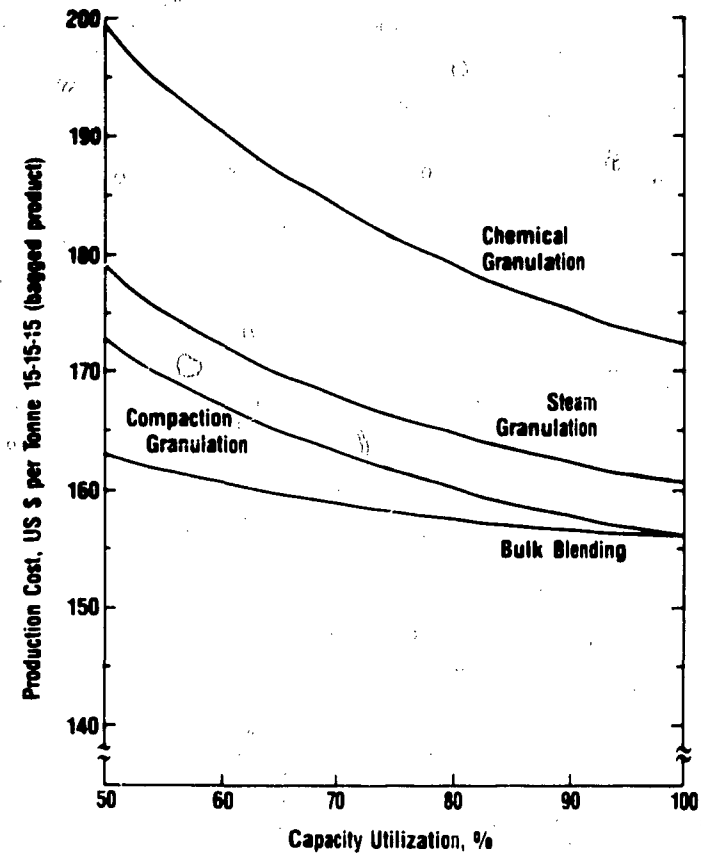

Figure 6. Effect of Capacity Utilization on Factory-Gate Production Cost for Various NPK Production Processes—New Facility (*12*).

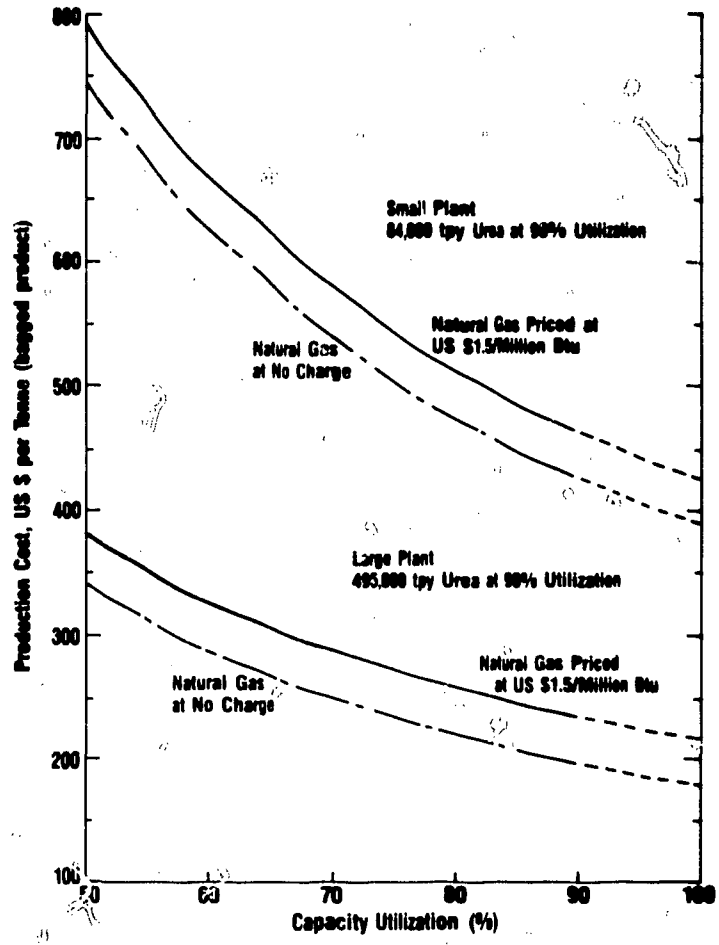

Figure 7. Effect of Capacity Utilization and Gas Price on Factory-Gate Production Cost of Urea—New Facility (*7*).

brings us back to the critical subject of demand forecasting, which was previously discussed. In general, if the demand for fertilizer is relatively high and stable (predictable), then it may be possible to invest quite heavily in a supply system based on local production. However, if demand is either low or erratic, such investments are usually not advisable. An example of an investment strategy that may be applicable to many sub-Saharan countries is shown in Figure 8. Of course, the point at which one supply method gives way to another depends upon the specific country and site, and any change should be thoroughly evaluated with regard to the many factors described in this paper.

From Table 7, it can be seen that only about 15% of the 40 countries in sub-Saharan Africa have an actual demand in excess of about 50,000 tonnes of nutrients (about 100,000 tonnes product). Thus, most of these countries will most likely be severely restricted in advancing beyond Step 2 or 3 as illustrated in Figure 8.

China, Brazil, India, Indonesia, Pakistan, Turkey, Bangladesh, and Mexico, for example, have made very large fixed capital investments in fertilizer production and distribution facilities, which were designed to decrease dependence upon imports of fertilizer and provide food security, whereas most other developing countries have not made such investments. Partially as a result of these large investments, as well as the need to maintain farm-level fertilizer prices that are economical to the farmer, various subsidies within the system (fertilizer production, distribution, and prices) were established. Currently, many of these countries, as well as others, are experiencing a considerable financial burden in the form of excessively high subsidies, as shown in Table 8.

Those countries in Africa—for example, Côte d'Ivoire, Cameroon, and to some extent Senegal—that have made substantial investments in fertilizer production facilities in the past but have not experienced a stable and expanding domestic demand for fertilizer have had difficulty in maintaining economic operation of their fertilizer production units.

Because the phosphate production facility in Senegal is oriented toward the export market, this country has

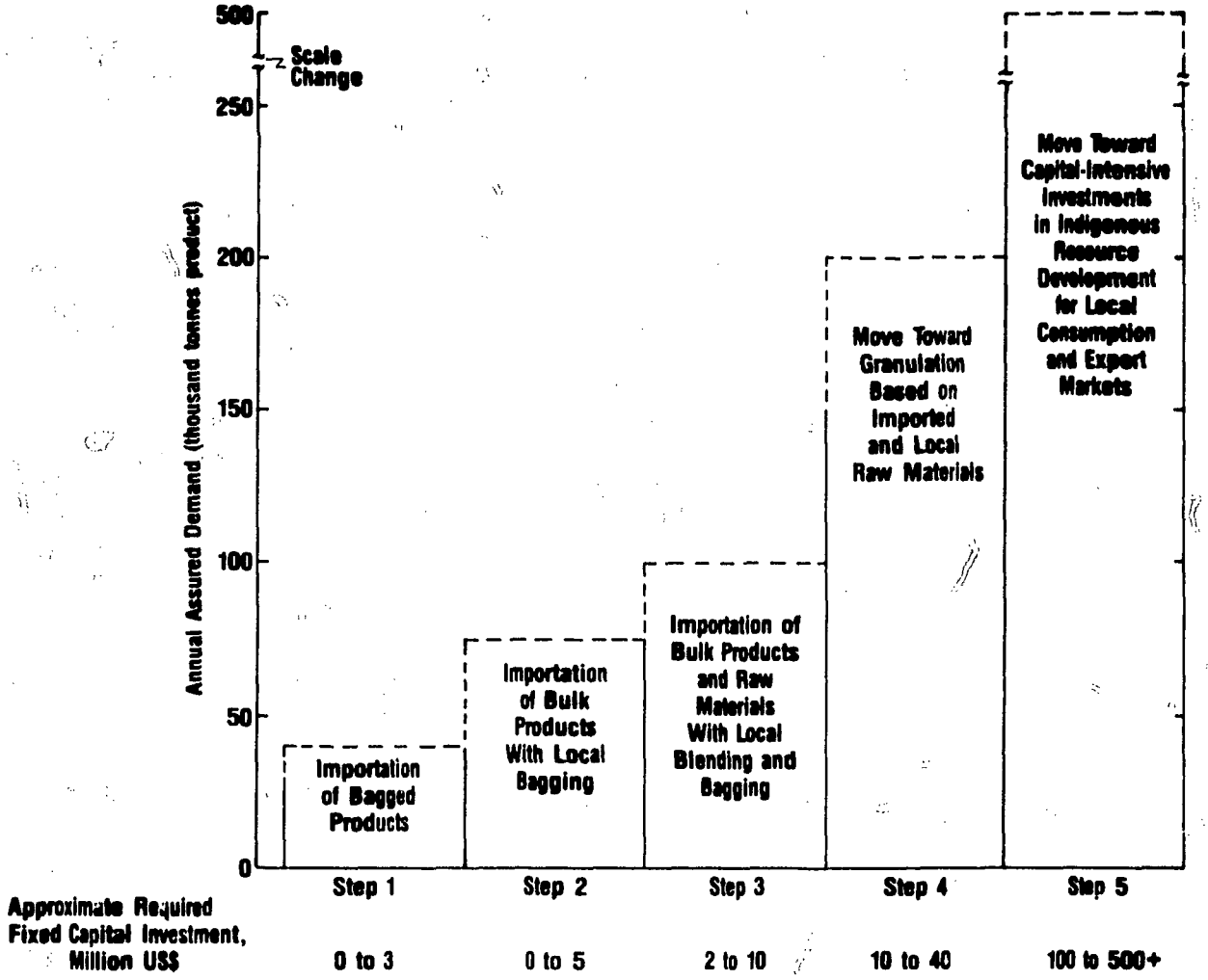

Figure 8. Example of Stepwise Development of Fertilizer Production/Supply Units.

Table 7. Annual Fertilizer Imports in Sub-Saharan Africa, Average for 1984-86[a] (*14*).

Fertilizer Nutrients	Fertilizer Product[b]	Number of Countries	Share of Total Imports
- - - - (thousand tonnes) - - - -			(%)
Less than 5	Less than 12	17	3
5-10	12-25	6	5
10-20	25-50	5	7
20-50	50-125	6	19
50-100	125-250	5	33
100+	250+	1	33
TOTAL		40	100

a. Indicated fertilizer imports account for about 90% of total consumption.
b. Tonnes of product estimated based on 40% average nutrient concentration.

Table 8. Estimated Cost of Fertilizer Subsidy in Selected Developing Countries That Have Invested Heavily in Domestic Production Units[a]

Country	Year	Consumption[b]	Subsidy Cost: Total	Subsidy Cost: Per Tonne Nutrient
		(nutrients)	(million US $)	(US $)
Bangladesh	1983/84	0.558	56	100
	1984/85	0.591	33	56
India	1983/84	6.63	919	139
	1984/85	8.00	1,546	193
	1986/87	9.63	1,443	150
Indonesia	1981/82	1.45	369	254
Pakistan	1982/83	1.24	130	105
	1983/84	1.20	72	60
	1986/87	1.78	74	42
Mexico	1984/85	1.66	365	220

a. Derived from reported data (*15,16*); 1986/87 subsidy data for India and Pakistan reported by FADINAP (*17*).
b. Million tonnes $N+P_2O_5+K_2O$.

obtained some relief during periods of low domestic demand through the export of finished fertilizers, for example, export of complex fertilizer (16-20-0) to Thailand in trade for rice. In addition, the sale of merchant-grade phosphoric acid to some of their joint venture partners (for example, India and Nigeria) has helped the Senegalese fertilizer industry maintain its economic viability.

In Cameroon, on the other hand, the superphosphate/NPK production facility constructed in the mid-1970s was closed after only 5 years of intermittent operation at low capacity, principally because the cost of production (based entirely on imported raw materials) was substantially higher than the cost of imported finished products. A similar situation has occurred in Côte

d'Ivoire, while in Madagascar a nitrogen (urea) plant built in the mid-1980s has never operated due to lack of foreign exchange for the purchase of imported naphtha for fuel and feedstock. Even if foreign exchange were available, it is unlikely that a urea plant based on competitively priced imported feedstock could be economical.

It remains to be seen if the recent investment by Nigeria in a grass-roots ammonia/urea/DAP/NPK production complex can result in economic operation. The Nigerian nitrogen production is based on local natural gas, whereas phosphate (phosphoric acid) and potash must be imported to the facility. Prospects appear to be reasonably good for this plant because domestic consumption of nitrogen in Nigeria is currently about 120,000 tpy, which is equivalent to about 50% of the new facility's nitrogen capacity in the form of urea. This, of course, assumes the Nigerian farmer can be convinced to use urea instead of CAN and other compounds as a principal source of nitrogen; meanwhile the existence of an economic export market for the excess urea has proven to be essential. In the final analysis, the economic viability of this facility will depend heavily upon the success it has in expanding the local nitrogen market and in securing economic export markets that will generate sufficient foreign exchange for the purchase of phosphate and potash raw materials.

The fertilizer supply and demand situation in Nigeria is likely to become even more uncertain in view of the Government's recently announced plan to dismantle the Government-operated Fertilizer Procurement and Distribution Division of the Ministry of Agriculture and transfer these functions to the private sector (*18*). Unless these changes are carefully phased in, monitored, and integrated with the Government's announced plans to decrease fertilizer imports and subsidies, a major disruption of fertilizer supplies at the farm level could occur.

Influence of Industry Ownership

When developing a fertilizer production/supply strategy, it is important to also carefully consider the trends occurring worldwide in the ownership of the industry (Figure 9). These trends can, and undoubtedly will, have a major impact on the long-term availability of raw and intermediate materials and, of course, on pricing. For example, the downward trend in international nitrogen prices since about 1980 appears to be partly due to increased government ownership of the industry. These downward trends are a reflection of government policies regarding fertilizer exports that in some cases were designed to generate foreign exchange for use by other sectors of the economy. Likewise, other government initiatives could have a major impact on the supply and pricing of a number of fertilizer products and intermediates.

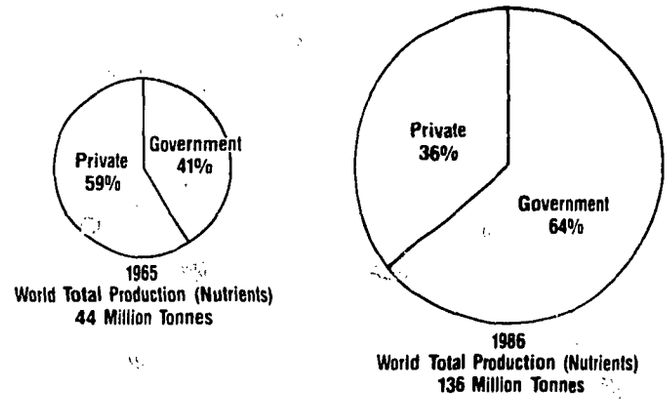

Figure 9. Approximate Distribution of Fertilizer Industry Ownership (Nitrogen, Phosphate, and Potash) *(19)*.

Role of Joint Ventures and Other Cooperative Production and Trade Agreements

For those countries having minimum financial and raw material resources and a relatively modest level of fertilizer consumption (restricted markets), it may be quite logical to explore collaboration with international overseas or regional partners. Such collaboration could be in the form of joint venture production units located in countries that have access to investment funds, economic sources of raw materials, technology, an existing industrial infrastructure, and the international trade and ocean transport facilities needed to broaden and serve the market. The scale of such joint venture production units could be large enough to result in economic production, which would be further enhanced by captive sales to joint venture partners at relatively stable prices insulated from the sudden fluctuations often seen in the international marketplace. The previously mentioned Senegalese phosphate production unit is one such example of a joint venture that is benefiting Senegal and India, Senegal's major joint venture customer for phosphoric acid.

If properly organized along the lines of actual fertilizer intermediate and product requirements, such joint venture collaboration could result in several benefits to the less developed countries including (1) security of fertilizer supply at reasonably stable prices, (2) a low level of debt and debt service, and (3) a low drain on foreign exchange, especially if the joint venture in fertilizer production is coupled with raw material and other commodity trade, for example, barter- and counter-trade agreements.

The concept of local and offshore joint ventures in fertilizer production is not limited to countries with small consumption. India, the world's fourth largest fertilizer consumer (almost 10 million tonnes nutrients), is

actively seeking ways to curb its investment in the fertilizer sector, slow the outflow of scarce foreign exchange, and maintain self-sufficiency. Offshore joint venture production units, particularly phosphate units, are being debated as one route to attainment of this goal (*20*).

It should be noted, however, that the effective operation of joint ventures and other forms of equity, resource, market, and trade collaboration depends heavily upon a sincere and continuing commitment of the partners that is often difficult to maintain because of restrictive government policies, difficulty in arriving at equitable pricing, and a host of political and institutional problems and anomalies.

Conclusion

Fertilizer consumption in sub-Saharan Africa has doubled during the past decade with about 50% of the total growth attributed to Nigeria alone. However, the whole of sub-Saharan Africa still only accounts for slightly less than 1% of the world's fertilizer consumption while the region accounts for about 9% of the world's population—a population that is currently growing at an annual rate of about 3%. The growth to date in fertilizer consumption occurred in the face of a number of technical, economic, and political constraints and thus adds credence to the proclaimed value of fertilizer.

Very steady growth occurred in the cotton sector, which historically has enjoyed the benefits of a sound management and technical infrastructure with a strong emphasis on fiscal responsibility. It is difficult to emulate such sound, integrated, and autonomous management characteristics on a widespread basis in a government setting where many different agencies are charged with separate aspects of agricultural sector development. Government agencies cannot always respond with the urgency needed by a farmer or other business organization whose immediate livelihood is totally dependent upon prompt and sound technical and financial decisions.

Government agencies need to move toward greater financial responsibility and autonomy at all levels of management, as typified by the private sector. Such an orientation will lead to decisions that are technically and financially sound and will result in an allocation of resources that is most likely to improve agricultural productivity. This increased productivity will occur, not only because of a more effective fertilizer production/supply and distribution system, but also because of improvements in fertilizer use, commodity pricing policies, and a host of related crop production components.

The decision to invest in local production facilities should be approached with a great deal of caution especially as it pertains to expected supply, demand, and pricing constraints and the continuing need for foreign exchange to repay the investment and to purchase the required raw materials and other inputs to sustain efficient and cost-effective operation. The combination of high-cost production units and modest or erratic markets in many sub-Saharan locations precludes heavy investments in local production units. Also, because the local market demand is usually quite small, competition among production units is unlikely; thus, the building of a production unit could lead to a monopoly on supply. Whether ownership is by government or by the private sector, such a monopoly on supply must be carefully monitored.

The overall situation in sub-Saharan Africa tends to favor a strong examination of the feasibility of joint ventures and other cooperative agreements to bring about cost-effective and secure supplies of fertilizers. Such arrangements may be manifested in the form of mixed (government and private) ownership of production and supply units, fertilizer and commodity trade agreements, and other forms of mutually beneficial economic and technological cooperation.

In summary, in both the short and long terms, improved efficiency in fertilizer production/supply and distribution in sub-Saharan Africa seems to be heavily dependent upon the degree of stability, management skill, and financial autonomy that is developed and effectively deployed throughout the entire agricultural sector.

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