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An Integrated Development Programme

for the

Fertilizer Industrial System in Ethiopia

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CONTENTS

Tables

Figures

ANNEXES

1. Utilization of Ethiopia's Geothermal Potential for FERTIS Development

2. Air Transport for the FERTIS in Ethiopia

3. Viability of Manufacturing Nitrogen Fertilizers from Ammonia produced by Water Electrolysis

Glossary

A (NH3):	Ammonia
Agricultural land:	In addition to the categories in "Arable land and land under permanent crops", this includes land under permanent meadows and pastures.
AN:	Ammonium nitrate
Arable land:	Refers to land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow or lying idle.
Arable land and land under permanent crops (ALPC):	This includes land under temporary crops, temporary meadows, land under market and kitchen gardens, land temporarily fallow or lying idle and also under permanent crops.
AS.	Ammonium sulphate
Base diagram:	A schematic representation of an industrial system. Depicts all the components of the system from demand for final products through to primary inputs. Illustrates the linkages between each component as well as the area of action of government policies. The base diagram permits a view of the extent of integration in an industrial system.
Bulk fertilizer:	Refers to unpacked fertilizer.
Bulk-blended fertilizer:	Two or more granular fertilizers of similar size mixed together to form a compound fertilizer.
CAN:	Calcium ammonium nitrate
Commercial fertilizer:	Refers to a material containing at least one of the primary nutrients in a form assimilable or "available" to plants in known amounts.
Complex fertilizers:	Refers to the compound fertilizer formed by mixing ingredients that react chemically.
Compound fertilizer:	Fertilizer containing two or more nutrients.
Country group:	A number of countries from a sample which based on a pre-defined set of characteristics, in this case FERTIS components, are more similar than other countries in the sample.
DAP:	Diammonium phosphate
DES:	Dietary Energy Supply (kcal per day per capita)

Development pattern:	The sum of readings on the level of development of all components making up an industrial system.
Fertility of soils:	Refers to the ability of soils to supply the plants with the essential nutrients needed to complete their life cycle.
Fertilizer:	Any material. organic or inorganic, natural or synthetic, that furnishes plants with one or more of the chemical elements necessary for normal growth. In this document the term "fertilizer" will be used in the sense of commercial fertilizer.
Fertilizer nutrient:	One of the three primary plant nutrients (N, P and K).
Fertilizer production:	Refers to production based on fertilizer raw materials (e.g. hydrocarbons, phosphate rock, sulphur, muriate of potash) and intermediaries (e.g. ammonia, nitric, sulphuric, and phosphoric acid).
FERTIS:	Fertilizer industrial system
GNR:	Grain Nutrient Ratio (kg/kg)
GR:	Ground phosphate rock
Grade:	The grade of a fertilizer is the nutrient content expressed in weight percentages of N, P2O5, and K2O in that order.
Granular fertilizer:	Refers to fertilizer in the form of particles, usually within the range of 1- 4 mm in diameter.
Industrial system:	The sum of productive capacities, supportive infrastructure and flows of goods and services resulting in the production of a given industrial output. Comprises one entire sector or several interlinked sectors or subsectors. The industrial system is composed f a set of production components, an institutional and policy framework. The components of a system are highly interdependent, in that any change in one component tends to modify the whole system.
Investment location factor:	Refers to investment costs above and beyond costs of a similar investment in Western Europe. An investment location factor of 2 on a fertilizer plant implies that investment costs would be twice the investment costs for the same plant in Western Europe.
KCl:	Potassium chloride or muriate of potash.
K2O:	Potash
Micronutrients:	Refers to elements required in small quantities. These are also known as trace elements.

Mixed fertilizer:	Refers to the compound fertilizer formed by mechanical mixing without chemical reaction (see bulk-blended fertilizers).
MOP:	Muriate of potash
N:	Nitrogen
NA:	Nitric acid
NG:	Natural gas
NP:	Nitrogen and phosphate. Also nitrophosphate fertilizers.
NPK:	Nitrogen, phosphate and potash. Also complex NPK fertilizers.
P2O5:	Refers to the phosphate nutrient. It is an oxide of phosphorous.
PA:	Phosphoric acid
PAPR:	Partial Acidulation of Phosphate Rock
Plant nutrient:	Any of the elements essential to plant growth.
Primary nutrients:	Refers to nitrogen, phosphorus and potassium.
Programme approach:	A methodology aiming to promote the integrated development of industrial systems. Comprises three interrelated stages which should usually be undertaken consecutively. The concept underlying all three stages is that of an industrial system. The development of an industrial system requires simultaneous actions across all components of the system to eliminate constraints affecting the operation of the system as a whole.
SA:	Sulphuric acid
Secondary nutrients:	Refers to calcium, magnesium and sulphur.
SOP:	Sulphate of potash
Straight fertilizer:	Fertilizer containing only one nutrient, e.g. urea or superphosphate.
TA projects:	Technical Assistance projects.
TSP:	Triple superphosphate
U:	Urea

Abbreviations and Units of Measure

ADB	African Development Bank
AIDB	Agricultural and Industrial Development Bank
AISCO	Agricultural Inputs Supply Corporation
CIF	Cost, Insurance and Freight
C&F	Cost and Freight
EAL	Ethiopian Airlines S.C.
EEC	European Economoic Community
EELPA	Ethiopian Electric Light and Power Authority
EGEP	Ethiopian Gas Exploration Project
EIGS	Ethiopian Institute of Geological Surveys
ELMICO	Ethiopia-Libya Mining Corporation
EVDSTA	Ethiopian Valley Development Study Agency
FAO	Food and Agriculture Organization of the United Nations
FOB	Free on Board (cost of goods excluding seafreight and insurance)
GDP	Gross Domestic Product
IAR	Institute of Agricultural Research
IDA	International Development Agency (World Bank Group)
IFDC	International Fertilizer Development Center
MCTD	Ministry of Coffee and Tea Development
MME	Ministry of Mines and Energy
MOA	Ministry of Agriculture
MOI	Ministry of Industry
MOTAC	Ministry of Transport and Communications
MSFD	Ministry of State Farm Development
MTSC	Maritime and Transit Services Corporation
NCC	National Chemicals Corporation
NFIU	National Fertilizer and Inputs Unit (of MOA)
ONCCP	Office of the National Central Commitee on Planning
PDSU	Programme Development Support Unit (of UNIDO)
PIP	Public Investment Program
TYPP	Ten Year Perspective Plan
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
WB	World Bank (International Bank for Reconstruction and Development)

Currency Unit: US $ 1 = 2.07 Birr.

Weights and Measures:

Mass is expressed in metric tonnes (t) or kilogrammes (kg). Mass flow is expressed in metric tonnes per year (tpy) or in metric tonnes per day (TPD). Area is expressed in hectares (ha). Energy units expressed in MBTU (million British Thermal Units (1= 0.252 Gcal) are recalculated to gicacalories (Gcal). Units of electricity are expressed in megawatts (MW) or megawatt hours (MWh).

Summary

This document presents a programme for the integrated development of Ethiopia's fertilizer industrial system (FERTIS) to the year 2005.

Fertilizer is an agricultural input of critical importance in reducing food imports, improving agricultural yields and increasing dietary energy supply (DES) per capita. Increased availability of fertilizer may help ameliorate the influence of recurrent droughts, soil degradation and the general weakness of Ethiopian agriculture.

Ethiopia has experienced a rapid growth of fertilizer consumption in recent years. The rate of growth of fertilizer consumption was around 18% per annum over the period 1986-1989, although consumption stagnated in 1990-91. All fertilizer is presently purchased through World Bank credits, and grants from the EEC and European Governments. The growing demand for fertilizer may justify establishment of a domestic fertilizer industry within an import substituting strategy.

Two major development options are possible for the Ethiopian FERTIS. Ethiopia could continue importing all fertilizer requirements, using soft loans from the World Bank and fertilizer grants. Alternatively, in order to avoid long-term dependency on imports and grants, Ethiopia could aim to establish a domestic fertilizer industry. The backbone of this industry would be the production of nitrogen fertilizers based on domestic natural gas.

The second option forms the basis of the long-term strategy proposed here. This option is also considered to be the most reasonable way of releasing the growing bottleneck in handling fertilizers at the port of Assab.

Ethiopia has the potential to attain considerable import substitution in nitrogen fertilizers as well as exports of potash fertilizers.

The following factors support FERTIS development in Ethiopia:

- The presence of natural gas and potash ores;
- Important hydroelectric and geothermal energy potential;
- Significant potential for increases in the area of irrigated land;
- Limited availability of cropland;
- Significant scope for improvement of extension services;

FERTIS development should be supported by intensive surveys and exploration for new sources of natural gas, phosphate rock, sulphur, limestone-dolomite and micronutrients.

Important constraints to the development of the system include:

- An unexploited raw materials base (phosphate and sulphur deposits are unexplored);
- Inadequate unloading, storage and transport capacities, especially in the port of Assab from where all imported fertilizers are delivered to central fertilizer stores in Nazreth, Mojo and Addis Ababa;
- Uncertain future access to the Red Sea coast and its principal ports in Assab, Massawa and Djibouti. This hinders long-term decision making regarding deliveries and handling of imported fertilizers;

- A weak transport network resulting in limited access to fertilizer even in surplus producing areas. Poor fertilizer distribution facilities raise prices, aggravating the low crop-fertilizer price ratio and the incentives of farmers to use fertilizer;

- Progressive degradation of arable land suitable for fertilization, resulting in irreversible losses of cultivable area due to severe soil erosion;

- Shortages of water in many regions and slow progress in expansion of irrigation. Although fertilizer is a vital component of an improved crop technology package, it is only after the water constraint is released that other constraints, such as nutrients supply, become important;

- Insufficient awareness of the optimum N:P:K nutrient ratio. Knowledge of the N:P:K ratio is required to design a long-term strategy for a domestic fertilizer industry;

- The long distance of natural gas deposits from cropping areas in highland regions;

- Generally weak infrastructure and relatively high investment location factors in undeveloped areas. These constraints pose an obstacle to the establishment of a domestic fertilizer industry that is competitive in international markets;

- Limited foreign exchange resources for implementation of investments relating to the FERTIS.

There are three distinct elements within an overall FERTIS development programme in Ethiopia. These are presented below:

(a) Consideration should first be given to possible advantages arising from competitive domestic production of fertilizers vis-a-vis increased fertilizer imports. Increased fertilizer aid, which is a medium-term strategy, could gradually replace structural and some emergency food aid.

(b) Increased fertilization of arable land under coffee, both from domestic fertilizer supplies and imports. Coffee is a principal foreign exchange earner in Ethiopia, despite which there is very limited application of fertilizer to expand coffee production and exports.

(c) Given abundant reserves of high quality potash ores a short distance from the Red Sea coast, and cheap sources of solar, geothermal and hydroelectric energy that might be used in potash development, an export oriented strategy for potash fertilizers should be given due attention in long-term development of the FERTIS.

Though projections of Ethiopia's fertilizer demand differ substantially, it can be assumed that fertilizer demand by the year 2005 may be as high as 650,000 tpy of pure NPK.

It is believed that as a consequence of continuous phosphate fertilization (mainly DAP), the residual phosphate content of the soils will rise. A major shift to nitrogen may be needed in future in order to keep agricultural yields high. Production of natural gas based nitrogen fertilizer is expected to be the core of any fertilizer industry in Ethiopia, and is thus given close attention in this Integrated Programme.

However, different estimates of the future optimum N:P ratio, which vary from 1:1.35 (low nitrogen demand) up to 1:0.5 (high nitrogen demand), require detailed examination in order to select an appropriate long-term FERTIS strategy.

Two main nitrogen import substituting options are considered in this Integrated Programme. These options reflect extremes in the N:P ratios noted above. Both options assume a fertilizer demand in the year 2005 of 650,000 tpy NPK. The two options are elaborated according to:

(1) Proposals of the National Chemicals Corporation, supported by a feasibility study of the International Fertilizer Development Center. This option is based on an N:P ratio of 1:1.35 (low nitrogen demand) and aims to construct a nitrogen fertilizer complex with a capacity of 450 TPD ammonia and 765 TPD urea at Gode, close to the natural gas deposit.

(2) Proposals of UNIDO, based on an N:P ratio of 1:0.5 (high nitrogen demand), aimed at pipelining natural gas to cereal cropping areas in the Ethiopian highlands and construction there of three nitrogen fertilizer complexes, each with a capacity of 500 TPD ammonia and 800 TPD urea.

The selection of nitrogen import substituting options involves comparisons of the costs of fertilizers purchased in the international market and delivered, through the port of Assab, to main cropping areas versus fertilizers produced domestically and delivered to the same areas. Achieving competitiveness with imports for a domestic nitrogen fertilizer industry is extremely difficult, although realistic opportunities exist.

The NCC option leaves a substantial fertilizer shortfall by the year 2005 and seems to be inadequately related to expected future nitrogen demand. The NCC option involves a single A/U complex located far from cereal cropping areas, to where urea would have to be transported by road, a factor that would reduce the competitiveness of the complex with imports. The location of the A/U complex at Gode, close to the natural gas deposit, will facilitate minimim investment (with a short pipeline) and urea manufacturing costs. This option is already advanced and may be implemented relatively soon.

The UNIDO option takes fuller account of future nitrogen demand, leaving a much smaller fertilizer shortfall by the year 2005. Location of three A/U complexes in cereals cropping areas aims at achieving a proper urea distribution pattern and a minimum transportation cost of urea by road. This option is characterized by a much higher initial investment cost (with a long NG pipeline to cropping areas). The first A/U complex would be scheduled 2 years later than that at Gode.

Though they may be considered to be complementary as far as nitrogen demand is concerned, options 1 and 2 are partially exclusive. This is because the justification for connecting the natural gas field with the highlands by a pipeline would be much weaker if Gode were selected for realization of the first A/U complex in Ethiopia.

Other conclusions resulting from a comparison of the NCC and UNIDO options include the following:

- The NCC option would lead to 22% import substitution, leaving 78% of the total nutrient demand in the year 2005 to be satisfied by imports. The UNIDO option leads to 54% import subsitution.

- The UNIDO option reduces transportation constraints to a minimum as it allows direct supplies of 0.75 million tpy of fertilizer to main cropping centers. This would leave about 0.5 million tpy of phosphate fertilizer (some 1,500 TPD) to be unloaded in Assab.

- The larger the domestic fertilizer capacities, the lower will be the traffic in the port of Assab (Djibouti, Massawa). If a domestic fertilizer industry is not established, over 4,000 tons of fertilizer would have to be unloaded each day and sent through the Assab corridor to central fertilizer stores. This would require a large expansion programme in the port of Assab (which would also have to unload grain and other goods).

- To satisfy nutrient demand in the year 2005, as much as 1.25 million tpy of fertilizer product would have to be delivered to agriculture, posing a major challenge to any domestic fertilizer industry and the transportation services.

- The UNIDO option involves construction of a 1,000 km natural gas pipeline to feed three nitrogen fertilizer complexes and would cost about US$ million 900. This option is much more expensive than the NCC option (which costs about US$ 350 million) but gives better results by the year 2005 in terms of fertilizer delivery to the farm gate. Both options are, in turn, more efficient than imports of fertilizers, even excluding the huge investment that would be needed for expansion of the port in Assab in the absence of any domestic fertilizer production.

- The NCC option (the A/U complex at Gode is to begin in 1994) is characterized by a time advantage of about 2-3 years and lower factory investment costs compared to the first phase of option 2 (an A/U complex at Yirga Alem). However, the fact that the UNIDO option is not prepared for immediate implementation seems to be outweighed by its long-term perspective.

Following comparative analysis of the two options, the UNIDO option is recommended as it better supports sustainable food self-sufficiency and higher dietary energy supply by the year 2005, even where the acreage of cultivated land is not expanded. Assuming a phased implementation, the UNIDO option secures NCC targets with a lower distribution cost, resulting in a lower estimated farm gate price for fertilizers. Maximum foreign exchange revenues are expected in the UNIDO option.

Knowing all the major advantages and disadvantages of both options, the Government will be in a position to decide which should be given priority. It is recommended however that both programmes be pursued until clear conclusions on NPK demand and an optimum N:P:K ratio emerge following a joint FAO/UNIDO Seminar. This Seminar should be organized at the earliest possible date.

Although some elements of the NCC option are considered sub-optimal, time and initial investment cost clearly favour this option. A proposal of ammonia production by electrolysis of water is thus made that might be considered complementary to option 1. The complementarity arises by adding more nitrogen (though urea cannot be produced by this route), and because the location of fertilizer facilities in the Blue Nile River Basin avoids investment in a long natural gas pipeline. This possibility is particularly interesting given the considerable hydroelectric potential in Ethiopia. It is suggested in this case that the hydropower plant at Finchaa could supply hydroelectricity for an ammonia/nitric acid/CAN complex.

Phosphate Fertilizer

Phosphate is the second primary nutrient given detailed attention in this Integrated Programme. The present N:P ratio of around 1:1.5 emphasizes phosphate, with DAP being the major fertilizer used.

Given a large demand for phosphate fertilizers, and the relatively long period necessary for developing the domestic raw material base (sulphur bearing raw materials and phosphate rock), the inadequate supply of this nutrient hinders balanced development of the FERTIS. Priority measures are required to improve the supply of this nutrient. Imports of phosphatic fertilizers are unavoidable for several years to come, until the domestic raw material base is developed.

In the light of low international prices of DAP and TSP in comparison with intermediates, and with uncertainties relating to the location of FERTIS facilities in the port of Assab, it is most likely that the idea of establishing a DAP/TSP/NPK complex in Assab (based on imported ammonia, phosphoric acid, phosphate rock and domestic potash) will have to be abandoned.

Therefore, development of indigenous deposits of Ogaden phosphate rock and Wollega apatite, to produce phosphate fertilizers domestically, is a prime consideration. Gode may prove to be well located for future production of nitrogen-phosphate fertilizers, rather than urea, and this location should be seriously considered. Potential fluorine contamination of drinking waters in the Rift Valley should be given special attention when identifying locations for phosphate fertilizer complexes.

Potash Fertilizer

A number of factors demand that an export oriented strategy in potash be treated cautiously. These factors include the limited demand for potash domestically and in Eastern-Southern Africa, world overcapacity and depressed potash prices, and the substantial investment needed for development of Ethiopia's potash deposit. Such a strategy might only be justified if the manufacturing cost of potash to be shipped to main international markets (India) is lower than the expected world price of potash at those markets. A preparatory phase of potash development at Dallol (with industrial-scale pilot facilities to match domestic demand) is therefore proposed here.

The Integrated Development Programme

Twenty technical assistance (TA) projects are proposed to implement this Integrated Programme. The programme addresses all major bottlenecks affecting the FERTIS. While recommending the UNIDO option for nitrogen fertilizers, the Integrated Programme can be structured around either this or the NCC option depending on Government decisions and the outcome of an updated assessment of fertilizer demand and the N:P:K ratio.

In addition to the purely technical nature of this assistance, relating not only to the chemical industry, energy, transport, agriculture and the environment, the proposed TA projects aim at strengthening national capabilities in procurement and trade, as well as planning investment in fertilizer plants and their operation and maintenance. A clear definition of long-term objectives and strategies for the fertilizer industry is of fundamental importance and is addressed in policy related projects.

Some African Development Bank Group operations in Ethiopia affect areas relevant to this Integrated Programme, as, logically, do a number of FAO's activites. Through its Emergency Recovery and Reconstruction Project, the World Bank aims to increase its assistance to Ethiopia. Most of the emergency inputs allocation for 1992/93 will be used to purchase fertilizers. Therefore, co-operation on development of the FERTIS in Ethiopia should be expanded and coordinated between the Government, the World Bank, the African Development Bank, UNDP, UNIDO and FAO. To this end, a conference of donors and international agencies on technical assistance projects relating to the FERTIS is proposed for the third quarter of 1992.

It is recommended that a FERTIS Steering Committee be formed, composed of representatives of different sectors of Ethiopia's economy and located at the Ministry of Industry. This committee would coordinate actions relating to FERTIS development.

To reap the full potential of Ethiopian agriculture, FERTIS development should be accompanied by a package of agricultural inputs including improved seeds, pesticides, irrigation and mechanization equipment. With proper development of the fertilizer industrial system the task of both nourishing and raising the living standards of future generations will be considerably assisted.

1. PROGRAMME CONTEXT

1.1 Description of the Fertilizer Industrial System (FERTIS) in Ethiopia

1.1.1 General Background

The following general features of Ethiopia bear an important relation to FERTIS development:

- Ethiopia is a unitary republic, with autonomous component regions. Eritrea has a de facto independent government pending a UN supervised referendum proposed for 1993.

- Ethiopia is a sea-side located country with a total area close to 1.2 million square kilometers, a potential agricultural area of about 80 million ha, and a potential arable area of about 18 million ha (Figure 1).

- The mid-1990 population is estimated at 51 million. With an average life expectancy of 46 years and an estimated population growth rate of 2.9%, the population is projected to reach 66 million in the year 2000 and 78 million in the year 2010.

- Agriculture contributes about 50% of GDP, providing a livelihood for up to 90% of the population. Agricultural exports account for over 90% of foreign exchange earnings. The most important food crops are teff, maize, sorghum, wheat, barley and millet. The chief cash crop is coffee, which is grown mainly on the south-west plateau but also in the central, southern and south-east regions of the country. Cotton and sugar are the other main cash crops. Recurrent droughts, climatic changes in the north of the country, deforestation, severe soil erosion, past conflict and transport problems have led to falls in agricultural production and depletion of livestock.

- The central highlands receive adequate rainfall. On the plateau there is a short winter rainy season and a monsoon season. Two crop cycles are thus possible. Actual and potential agricultural surplus producing areas are located here (Figure 2). Much of the lowlands, including south-east regions and the Rift Valley, have a Sahelian climate, being very dry and hot with a short wet season. A desert climate prevails at the Red Sea coast and in the eastern part of the Ogaden province.

- Figures for 1984-86 indicated a daily per capita calorie intake of as low as 1,400 - 1630 kcal (2,097 kcal was the average figure for sub-saharan Africa in 1986).

- With a per capita GNP in 1986 of US $120 Ethiopia is one of the world's poorest countries. In 1987 the external debt stood at US $ 2.4 billion.

- The port of Assab in Eritrea plays a key role in Ethiopia's FERTIS, and its importance will grow substantially in the coming years. Through this port and the associated road network (the Assab corridor) all imported fertilizers are transported for storage in Nazreth, Mojo and Addis Ababa (Figure 1). Future political decisions regarding Eritrea and access to the port of Assab are thus of prime importance to the FERTIS. Assab has been declared a free port under Eritrean sovereignty with a charter guaranteeing Ethiopian access during the transitional period. The only

Figure 1

MAP OF ETHIOPIA WITH MAJOR TRANSPORTATION ROUTES

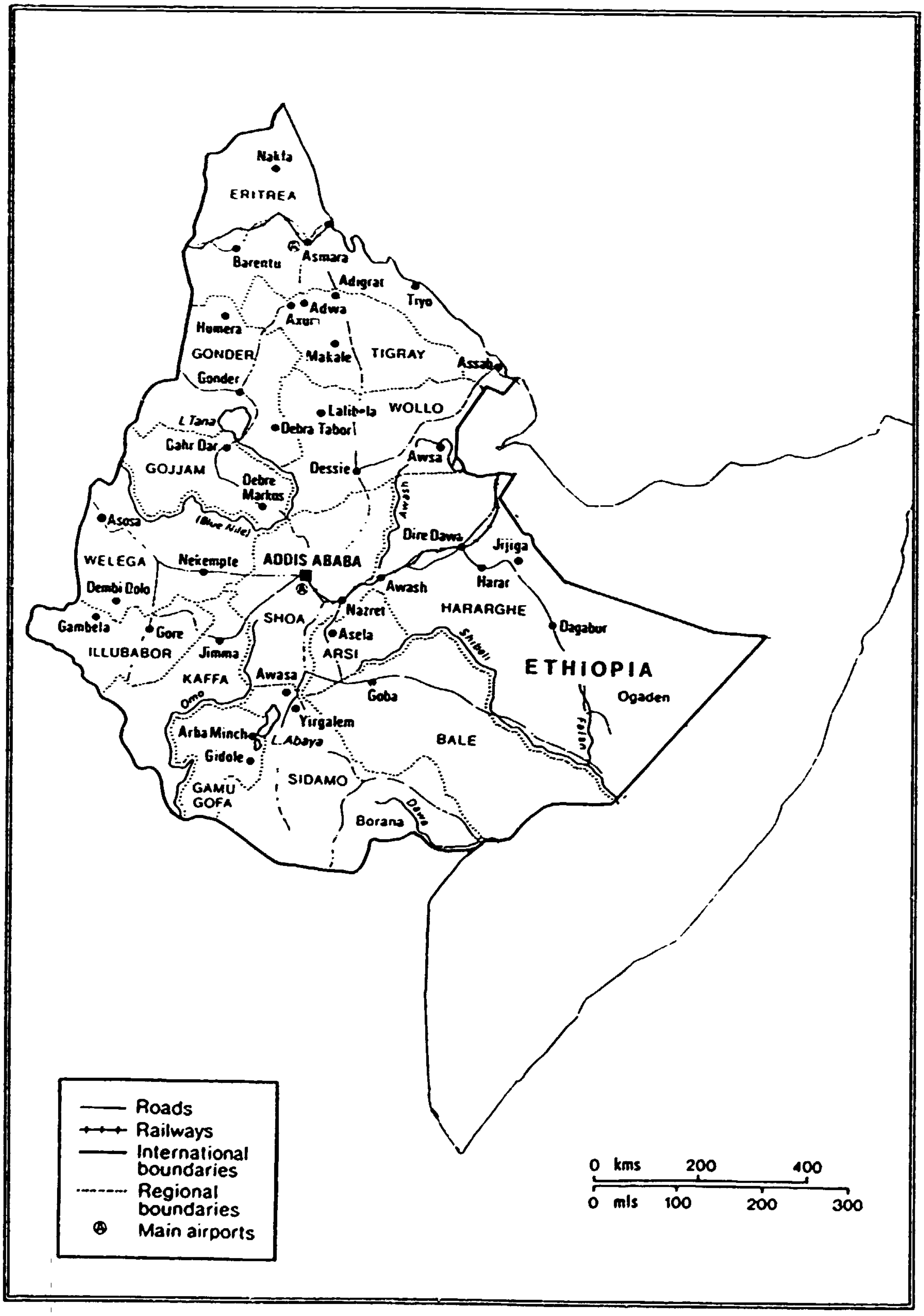
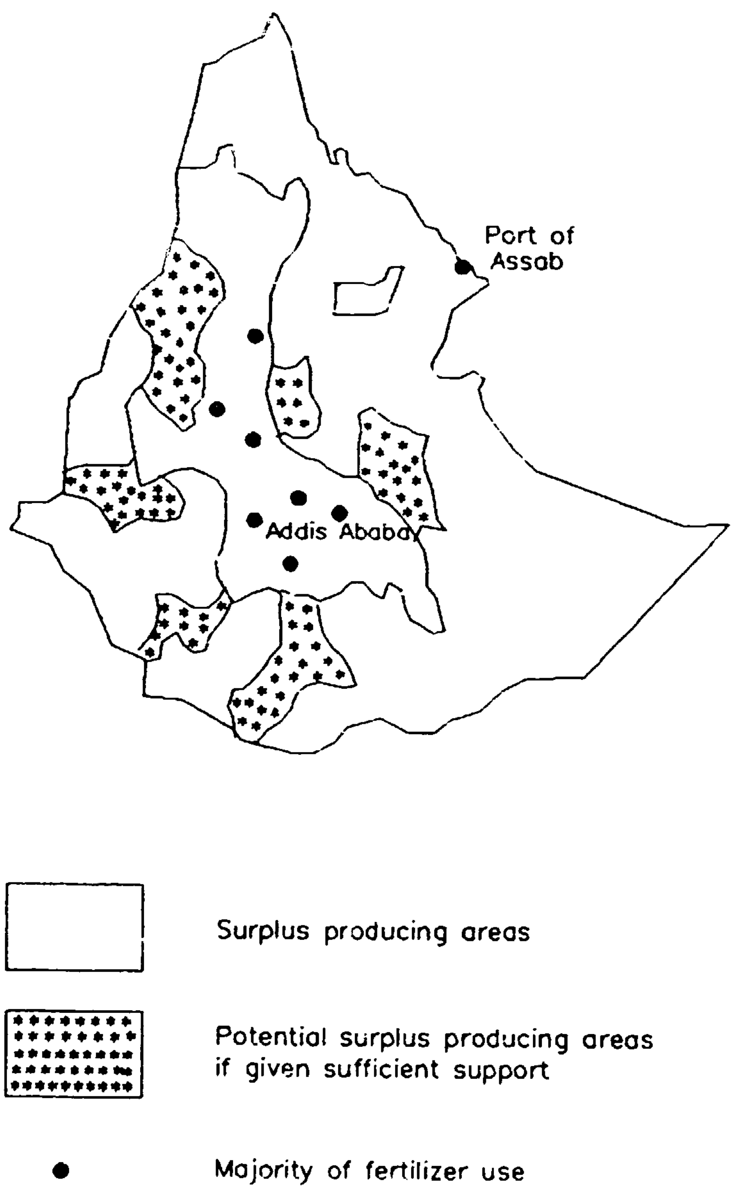


Figure 2

LOCATION OF AGRICULTURAL SURPLUS PRODUCING AREAS IN ETHIOPIA



Source: Ministry of Agriculture

rail line connects Addis Ababa with the foreign port at Djibouti, which is at the present time of secondary importance to FERTIS development. However, because of the expected heavy traffic through Assab, the port of Djibouti may become more significant, especially if access to Assab should be limited.

- The mining sector, of vital importance to FERTIS development, contributes only marginally to GDP and is limited to small-scale extraction of gold. Reserves of potash ore are not mined. Phosphate rock in Ogaden, apatite in Wollega and sulphur deposits in the northern part of the country (native sulphur and copper and zinc pyrites) are as yet unexplored.

- The energy subsector possesses considerable hydro-electric potential (an estimated 1,200 megawatts). Crude oil imports are processed to petroleum products in the Assab refinery (with a capacity of 18,000 barrels per day). Prospects exist of finding petroleum onshore in the Danakil area and offshore along the Red Sea coast, as well as in the Ogaden region. Oil exploration is slowly progressing in the south-west of the country and has accelerated lately in seven blocks on the Red Sea coast. Important reserves of natural gas have been discovered in the Ogaden region at Calub. Total proven reserves are estimated at about 78 billion cubic meters and are being developed with World Bank support. Wood is a traditional source of energy, but it is hoped that increased availability of hydroelectricity and natural gas will reduce fuelwood use as many forests are severely depleted, leading to soil erosion.

- Until 1991, Western governments had been critical of rural development policies, which included collectivisation of agriculture. Some Western countries had refused to give long-term development aid, preferring to give assistance in the form of short-term emergency relief. Longer-term assistance had been left to multilateral bodies like the World Bank, the African Development Bank and the European Investment Bank. The World Bank lent more than U.S.$ 100 million for forestry, livestock and drainage schemes during 1987. Upgrading of the Assab port was also under consideration by the World Bank, as were various road improvement schemes. The European Investment Bank had committed funds to soil conservation.

- After political changes in 1991 international assistance to Ethiopia improved dramatically. An assistance package from the World Bank and donor organizations (Emergency Recovery and Reconstruction Project) in the range of US$ 500 million was being considered in late 1991. Nearly half of the allocation for Ethiopia's economic recovery and the restoration of social services is to go to the productive sectors and a quarter to the renovation of physical infrastructure. The emergency inputs allocation covers about US$ 86 million for 1992/93, more than 50% of which will be used to purchase fertilizers. Preparation of this project followed close collaboration between the World Bank, and donor organizations, including EEC, the ADB, and the governments of Italy, Japan, the Netherlands, Sweden, and the USA. The World Bank is expected to finance, through the International Development Association (IDA), over half of the the total package, with other donors providing the balance. The package is to be made available in early 1992.

1.1.2 FERTIS Development Phases

Market development

Three generic stages of fertilizer use can be distinguished based on average fertilizer nutrient consumption on arable land with permanent crops. These stages are presented in Table 1:

Table 1: Stages of Fertilizer Use

Stage	Characterization	Duration	NPK Application Per Hectare of Arable Land with Permenant Crops
Stage I	Introduction	15 - 20 years	10 kg
Stage II	Take-off	50 - 60 years	300 kg
Stage III	Maturity	Indefinite	300 kg

With its fertilization rate of 5 kg of NPK/ha of arable land with permanent crops, Ethiopia is in the first, introductory stage of development of the fertilizer market. Rapidly growing consumption of fertilizers and fertilizer delivery to surplus producing areas, mostly in Arsi, Shewa, Gojam and Keffa means that these zones have already reached the second stage in the development of the fertilizer market.

Industrial development

As a general rule, the development of a fertilizer industry follows four distinct phases:

1. Imports of food and simultaneous introduction and demonstration of the effects of fertilizer use;

2. Imports of fertilizers to satisfy local demand and preparation of conditions that enable development of a domestic fertilizer industry;

3. Construction of fertilizer plants and facilities, often with aid and foreign technical assistance;

4. Domestic production of fertilizers through unaided exploitation of fertilizer plants and complexes, imports being limited only to raw materials or intermediaries not available domestically.

In order to enter phase 3 it is usually necessary to pass through phase 2 (imports of fertilizers). This is because the affinity of fertilizers to local soils must be checked, the response of crops to fertilizers should be analyzed, a fertilizer distribution network should be created, and, among many other possibilities, local phosphate rock grinding, compound granulation or bulk-blending and packing of imported fertilizers may be initiated.

Ethiopia is presently in the second industrial phase, aiming to create a domestic fertilizer industry and to enter the third phase. Both import substitution (nitrogen) and export promotion (potash) are being considered.

1.1.3 The Fertilizer Sub-sector in Ethiopia

Ethiopia does not produce fertilizer and depends on imports and grants. Ammonia, sulphuric acid and phosphoric acid are not yet manufactured.

Only two types of fertilizer are currently used, diammonium phosphate (DAP) and urea (U). DAP is the main source of phosphate and nitrogen, urea supplements the balance of nitrogen. This situation is understandable as DAP and urea are the most concentrated fertilizers, which allows the unit cost of nutrients to be kept to a minimum. The total amount of fertilizer purchased in 1989 amounted to 170,000 mt of product, equivalent to about 100,000 mt of NP. The N:P nutrients ratio has fluctuated in the range of 1:1.1 to 1:2.5, with a ratio of about 1:1.5 prevailing in recent years. The consumption of NP nutrients has increased considerably since 1961, as shown in Table 2.

Table 2. Consumption of NP in Ethiopia (1961-1991) (000's tpy of N+P205)

	1961-66	1971	1973	1976	1979	1981	1985	1988	1989	1990	1991
NP	1	7	19	27	37	46	66	79	98	88	87

Potash has not been widely used and domestic soils do not show a general potash deficiency. Small amounts of potash were imported, in the form of NPK fertilizers, for the Ministry of Coffee and Tea Development.

Demand for fertilizers has grown rapidly and is estimated to be almost twice as high as present consumption. Fertilizer applications to AISCO in 1990 reached 290,000 mt, providing an indication of the demand for fertilizer that remains latent due the shortage of foreign exchange. Assuming the same pattern of consumption of fertilizers as in 1989, the demand for fertilizer nutrients in 1990/91 would be as high as 175,000 mt of NP. Three highland regions, Shewa, Arssi and Gojam, contribute some 45% of national food production and account for about 75% of total fertilizer consumption. The lowlands have insufficient rainfall and are mostly pasture soils where nomadic societies use almost no fertilizer at all.

The Agricultural Inputs Supply Corporation (AISCO), which operates under the Ministry of Agriculture (MOA), has sole responsibility for the procurement and distribution of fertilizers. For purchases of fertilizers, procured by AISCO under open international competitive bidding, the World Bank provides soft loans (10 years grace period, 35-40 years repayment period, and a rate of interest below 1%). Reimbursement of this loan is made according to a supplementary agreement between the IDA and the AIDB (which applies its spread for the loan, and also covers foreign exchange risk). There are no interest payments on fertilizer grants from EEC countries. A counterfund account is located in the Office of the National Commitee for Economic Relations (ONCFER). For fertilizer grants from the Government of Italy either, a counterfund account is located in the Italian Embassy in Ethiopia, from which funds are available for a Rural Development Project in Arsi province.

All purchases of fertilizers are paid by AISCO in local currency on a CIF or C&F Assab basis. AISCO purchased 162,000 mt, 146,000 mt, and 141,000 mt of fertilizer respectively in 1989, 1990, and 1991, comprising about 80% DAP and 20% urea. Table 3 provides information on cost, weight and the terms of purchase for fertilizer imports between 1985 and 1991.

Table 3

FERTILIZER IMPORTS DURING 1985-1991G.C. (1977-1983 E.C.)

Year	Source of funds	Type of fertilizer (MT)			Unit cost(Birr)		Total Cost (Birr)			Term/purchase		Type of aid	
		DAP	Urea	Total	DAP	Urea	DAP	Urea	Total	DAP	Urea	DAP	Urea
1985	World Bank	25,200	-	25,200	511	-	12,874,076	-	12,874,076	C&F	-	Credit	
	FAO	-	7,997	7,997	-	543	-	4,337,347	4,337,347	-	CIF		Grant
	Subtotal	25,200	7,997	33,197			12,874,076	4,337,347	17,211,420				
1986	World Bank	26,250	-	26,250	470	-	12,353,630	-	12,353,630	CIF			
	Ethiopian Govt.	76,762	27,616	104,378	460	258	35,251,180	7,119,850	42,371,030	C&F	C&F		
	FAO	-	1,575	1,575	-	497	-	782,460	782,460	-	CIF		Grant
	EEC	-	5,000	5,000	-	350	-	1,750,615	1,750,615	-	CIF		Grant
	Subtotal	103,012	34,191	137,203			47,604,810	9,652,925	57,257,730				
1987	Ethiopian Govt.	105,610	15,750	121,360	394	285	41,516,090	4,482,844	45,998,934	C&F	C&F		
	EEC	-	5,000	5,000	-	350	-	1,750,615	1,750,615	-	CIF		Grant
	Subtotal	105,610	20,750	126,360			41,516,090	6,233,459	47,749,540				
1988	Ethiopian Govt.	110,750	23,262	134,012	527	304	58,354,070	7,061,690	65,415,760	C&F	C&F		
	Subtotal	110,750	23,262	134,012			58,354,070	7,061,690	65,415,760				
1989	World Bank	44,000	6,000	50,000	565	384	24,856,643	2,303,910	27,160,553	CIF	CIF	Credit	Credit
	EEC	35,000	26,200	61,200	603	454	21,091,025	11,622,823	32,713,848	CIF	CIF	Grant	Grant
	Italian Govt.	19,000	-	19,000	580	-	11,002,567	-	11,002,567	C&F	-	Grant	
	Ethiopian Govt.	30,000	-	30,000	580	-	17,372,475	-	17,372,475	C&F			
	Subtotal	128,000	32,200	160,200			74,322,710	13,926,733	88,249,440				
1990	World Bank	22,500	6,000	28,500	500	333	11,243,534	1,998,378	13,241,912	CIF	CIF	Credit	Credit
	EEC	38,000	25,000	63,000	475	403	18,032,923	10,076,245	28,109,168	CIF	CIF	Grant	Grant
	Italian Govt.	19,000	-	19,000	510	-	9,698,778	-	9,698,778	CIF		Grant	
	Ethiopian Govt.	35,000	-	35,000	570	-	19,949,252	-	19,949,252	CIF			
	Subtotal	114,500	31,000	145,500			58,924,487	12,074,623	70,999,110				

Source: AISCO

Table 3 (contd.)

Year	Source of funds	Type of fertilizer (MT)			Unit cost(Birr)		Total Cost (Birr)			Term/purchase		Type of aid	
		DAP	Urea	Total	DAP	Urea	DAP	Urea	Total	DAP	Urea	DAP	Urea
1991	World Bank	72,500	6,000	78,500	528	445	38,227,104	2,668,437	40,895,541	CIF	CIF	Credit	Credit
	EEC	30,000	10,194	40,194	452	602	16,237,102	6,139,460	22,376,562	CIF	CIF	Grant	Grant
	Italian Govt.	19,900	2,546	22,446	557	605	11,070,619	1,542,382	12,613,001	CIF	CIF	Grant	Grant
	Subtotal	122,400	18,740	141,140			65,534,825	10,350,279	75,885,100				
	GRAND TOTAL	709,400	168,140	869,615			359,131,000	63,637,050	422,768,124				

Source: AISCO

A fleet of trucks delivers fertilizers to central stores in Nazreth, Mojo and Addis Ababa. AISCO employs the government owned Ethiopia Freight Transport Corporation for this purpose as well as for distributing fertilizers to other regions. Through a planned purchase of 50 truck-trailers, AISCO aimed to transport up to 50% of fertilizers distributed from central stores. AISCO supplies fertilizers, and other inputs, to an extensive network of marketing centers for retail sales through Service Cooperatives to Peasant Associations and Cooperatives. Around 750 Selling Distribution Centers deliver fertilizers to over 4,000 Service Co-operatives. These co-operatives supply peasant farms, which account for over 70% of total fertilizer use. With World Bank funds AISCO was expected to buy 3 mobile fertilizer bagging units.

Of the estimated potential of 80 million ha of agricultural land, Ethiopia's arable land potential (cropland) is around 18 million ha. However, only about 7 million ha is under cultivation at present. The level of fertilization stood in 1989 at 5 kg of NPK per ha of arable land with permanent crops (14 kg of NPK per ha of cultivated area).

1.1.4. Fertis Main Components and Linkages in Ethiopia

This section provides a description of the components of Ethiopia's FERTIS. Figure 3 is a base diagram providing an illustration of the main components in a fertilizer industrial system as well as the interlinkages between components. Figure 4 illustrates the FERTIS components existing today in Ethiopia. The following sections can be related to the components of a FERTIS depicted in figure 3.

(a) Natural resources

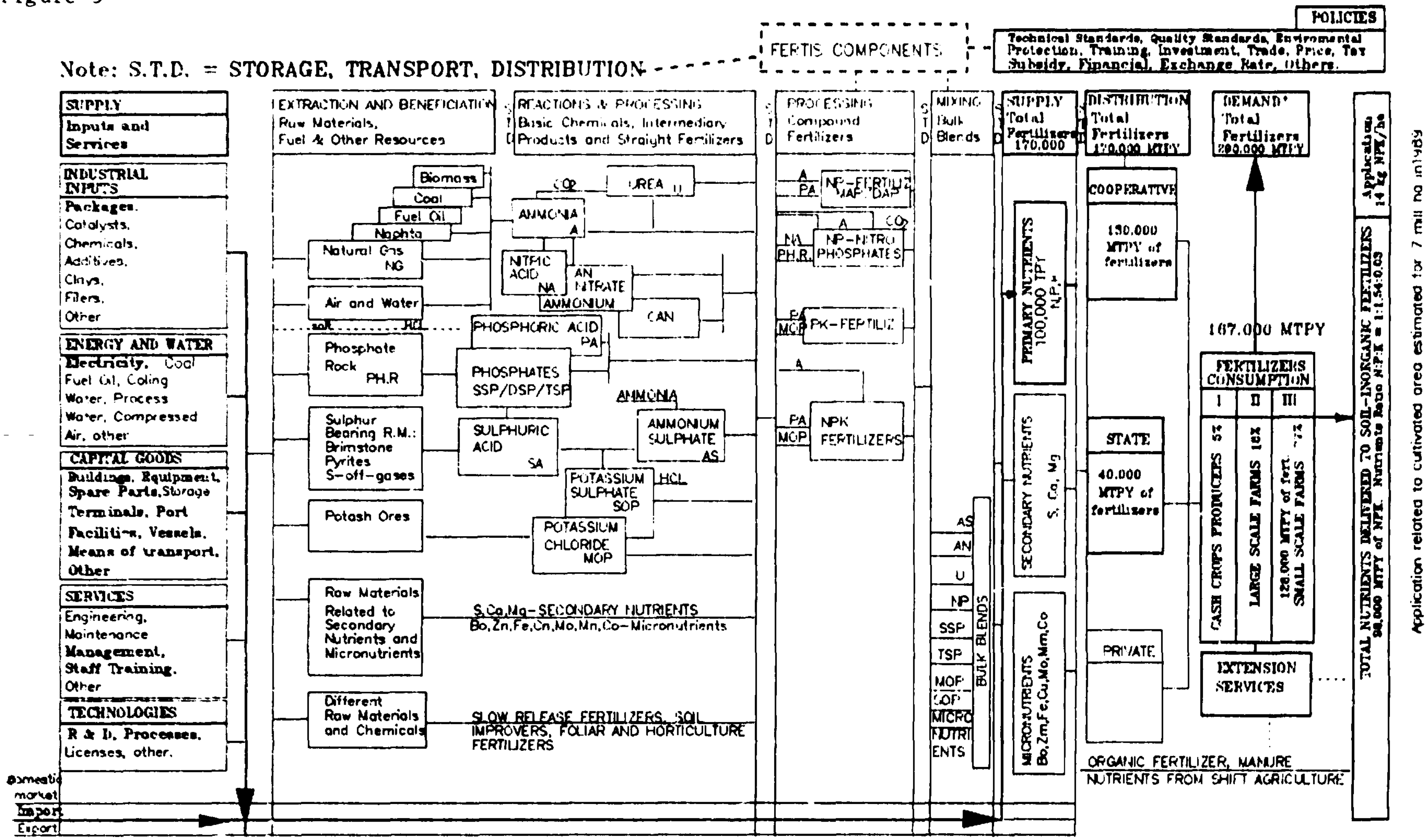
Ethiopia is endowed with Nitrogen (N) and potassium (K) related raw materials, natural gas and potash ores. Natural gas reserves estimated at about 78 billion cubic meters have been discovered and are being developed in the Ogaden region.

A prefeasibility study funded by the World Bank has been carried out by the Gas Development Corporation (USA). The study identified a number of small scale gas utilization projects (domestic and industrial fuel, vehicular fuel, electricity generation) which have been initiated with World Bank funding.

One of the small gas utilization projects considered establishing a mini-fertilizer nitrogen plant at Gode, about 100 kms from a major natural gas deposit at Calub. The government was also looking at a large scale gas utilization scheme in which as much as 1.2 billion cubic meters of natural gas would be sent through pipelines from Calub to Addis Ababa. This scheme included the establishment of a world-scale ammonia and urea fertilizer complex at Metahara. Such a complex would use up to 0.5 billion cubic meters of gas per year. Existing natural gas reserves of 78 billion cubic meters could feed the complex for about 65 years, even if other large consumers were included in this scheme. Both plans have been abandoned, at least temporarily. The National Chemicals Corporation (NCC), a parastatal organization under the MOI, plans to establish an ammonia/urea complex at Gode with a capacity of 450 TPD of ammonia (A) and 765 TPD of urea (U).

Figure 3

"FERTIS" - FERTILIZER INDUSTRIAL SYSTEM IN ETHIOPIA 1989

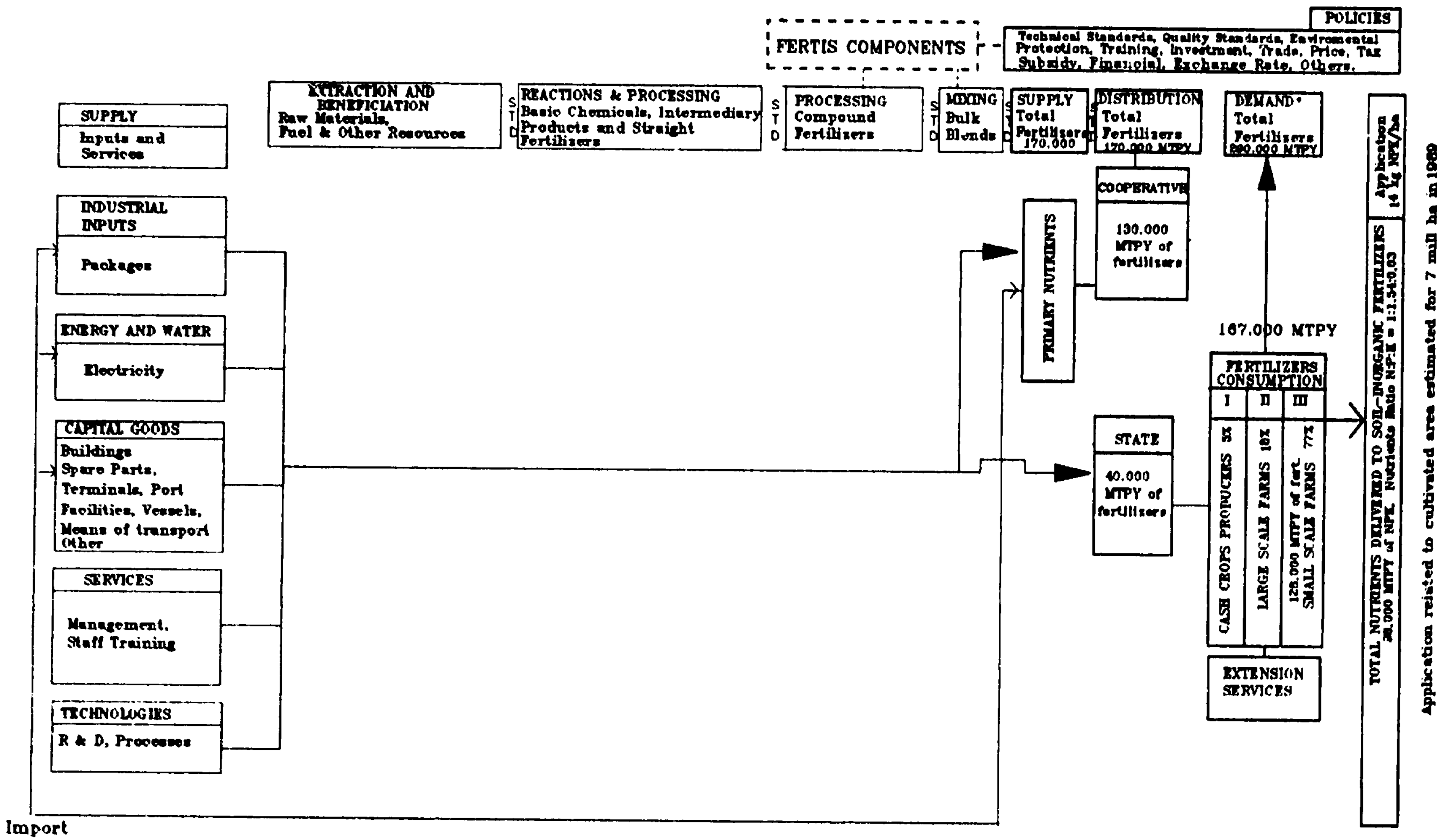


AISCO purchased in 1989 161,500 mt of fertilizers of that 129,300 DAP and 32,200 mt urea, i.e. 38,100 N + 59,500 P_2O5. Total NP 97,600 mt; N:P = 1:1,56. AISCO purchased for the Ministry of Coffee and Tea also 8,250 mt of NPK fertilizer 1:1:1.
Total value of purchased fertilizers CIF Assab bagged products approx. 44 mill. USD, i.e. 91 mill Birr.
Total value of fertilizers at the farmer's gate approx. 137 mill. Birr.

*Note: Demand for 1989 almost 2 times higher than consumption.

Figure 4

"FERTIS" – FERTILIZER INDUSTRIAL SYSTEM IN ETHIOPIA 1989



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Total value of fertilizers at the farmer's gate approx. 137 mill. Birr.

*Note: Demand for 1989 almost 2 times higher than consumption.

Note:
S.T.D. = STORAGE, TRANSPORT, DISTRIBUTION

The project has been developed by NCC together with the International Fertilizer Development Center (IFDC), USA and ICI, UK. A complete feasibility study for this project, which is the most advanced of all FERTIS projects analyzed in this document, was prepared by the IFDC.

The Government has offered seven cil blocks to Western companies in the Red Sea coast. The probability of discovering associated deposits of natural gas is considered high.

Potash deposits are located in the Danakil Depression, some 90 km from the port of Mersa Fatma on the Red Sea Coast. The deposits have been worked intermittently since the turn of the century. In 1981 an Ethiopia-Libya joint venture (ELMICO) acquired the deposit and initiated a pre-feasibility review. Due to military conflict in the area in recent years the pre-feasibility work was not completed.

The potash deposit has a number of attractive characteristics. The ores are close to the surface, permitting cheaper open pit and/or solution mining. In addition to sylvite (containing an average of 33% potassium chloride) and carnallite, kainite could also be mined to produce potassium sulphate. Estimated potash reserves range from 10-18 million mt of recoverable KCl product. The projected production of 1.5 million tpy of KCl might be directed to markets in Asia and Africa. In this respect the deposit is advantageously located, being close to the coast and to harbour facilities.

However, the World Bank indicates poor market prospects for potash, which places the economics of the project in doubt. The World Bank has also noted that the deposits would need an extensive programme of technical work, as well as a technically and financially qualified partner. Penetration of the Asian market, which consumes about 2.8 million tpy of KCl, would also be a major undertaking. The project would need to offer a substantial price advantage and reliability of supply.

Feasibility work on the Dallol potash deposit has been delayed because of financial problems at ELMICO. A meeting of ELMICO's shareholders (51% Ethiopia and 49% Libya) is scheduled for January/February 1992, where decisions on this 25 years agreement (of which 10 years have already passed) are to be taken.

The two remaining raw materials of great importance to FERTIS development in Ethiopia, sulphur and phosphate, are found in several locations. Further exploration is required however. Sulphur and pyrite deposits are located in Eritrea, Tigre, Harar and Shoa provinces.. An exploration programme begun in 1985 by a joint Ethiopian Institute of Geological Surveys-UNIDO team proved the existence of phosphate bearing rock in the Ogaden as well as apatite associated with magnetite and ilmenite in the Wollega and Bale regions. Sulphur from the manufacture of phosphate fertilizers may also be used as a secondary nutrient when applied in such fertilizers as ammonium sulphate, single superphosphate and potassium sulphate.

Prospects for development of a sulphuric acid industry by the year 2000 on the basis of domestic raw materials seem to be remote. This is due to the time required to survey, to test on a pilot-scale, extract and beneficiate domestic sulphur bearing raw materials.

(b) Processing to Intermediary Products

Ammonia, sulphuric acid and phosphoric acid have not yet been manufactured in Ethiopia. A small-scale sulphuric acid plant is being built in Nazreth based on imported brimstone. Sulphuric acid will be used for production of aluminium sulphate used for water treatment. The best prospect for manufacture of intermediary products exists with ammonia plants based on domestic resources of natural gas. Ammonia plants based on water electrolysis cannot compete economically with natural gas based ammonia plants due to electricity prices for industrial users of 10 US cents per kilowatt-hour (100 US $/MWh). The comparison looks much more favourable if the cost of hydroelectricity, or other sources of electricity is low.

It is very likely that by the year 2000 processing to ammonia will have been developed. However, little prospect exists for development of the domestic phosphoric acid industry by that time.

(c) Processing of NPK fertilizers

Processing of NPK fertilizers has not yet been developed in Ethiopia.

Urea is a priority in FERTIS development plans which include an 800 TPD urea plant at Gode. Due to the raw material base and market constraints, small capacity MOP (SOP) plants at Dallol are expected to be established next.

Because of high prices of ammonia and phosphoric acid relative to DAP, plans to build a versatile DAP (TSP) plant at Assab cannot be encouraged.

(d) Other operations (bulk-blending, ground phosphate rock plants)

These operations have been the subject of intensive studies in the past. Today, however, these options have been abandoned in favour of the synthesis of fertilizer products. It is obvious, however, that with increased awareness of fertilizer affinities to local crops and soils, different grades of complex or blended NPK fertilizers will be applied. Technical assistance (TA) project 17 of this Integrated Programme aims to support this process.

Grinding of phosphate rock and the PAPR process may be developed in future close to phosphate mines, once phosphate deposits are developed.

Packaging industry development (TA project 18) is being considered in order to decrease foreign exchange expenditures by importing bulk rather than bagged fertilizers.

(e) Energy self-sufficiency and energy consumption per capita

Energy self-sufficiency and energy consumption per capita are a measure of energy inputs essential to FERTIS development. Linkages between the fertilizer industry and the energy sector (electricity, gas, coal, oil and refinery products), play a crucial role in uninterrupted fertilizer production, especially for processes characterized by high energy requirements (e.g. ammonia through water electrolysis, phosphoric acid through wet and thermal processes, and others).

Ethiopia has a low level of development of the energy sector. The country had a total energy self-sufficiency of about 9% in 1986, and a significant hydro-electricity potential. Ethiopia is a net exporter of electricity to Sudan and Djibouti. Energy consumption per capita is one of the lowest in the world at 21 kg of oil equivalent in 1986. Prospects exist for improvement in the energy sector, particularly in further hydro-electricity development, utilization of natural gas (TA project 8) and geothermal energy (Annex 1 and TA project 15). The possibility also exists of discovering oil, exploration for which has intensified.

The development of the energy sector is very important in limiting the process of deforestation (fuelwood gathering), which leads to severe desertification and reduction in the potential for cultivable land expansion.

(f) Storage, transport and distribution

Considerable constraints are evident for FERTIS development in storage, transport and distribution.

Ethiopia has a large area and a mountainous landscape crosscut by the Rift Valley. While the road network is sufficiently developed, with some major exceptions, the quality of roads is poor, especially in peripheral areas, and freight costs are high relative to most countries. There is limited access to the Red Sea coast, through the ports of Assab and Massawa. There is only one rail link, between Addis Ababa and the port of Djibouti. There are fertilizer stores in the port of Assab, once operated by Ethiopia Amalgamated Limited, with a capacity of 15,000 tonnes for bulk and 10,000 tonnes for bagged product, with bagging facilities. These facilities require upgrading. Ships are unloaded by general cargo port facilities that also handle bagged fertilizers.

With expected demand for fertilizer products in the year 2005 as high as 1.25 million tpy, the port of Assab will be overloaded with fertilizer, grain and other materials if complex expansion programmes are not implemented in the coming years. Such programmes must address both fertilizer unloading/storing and loading/transporting capacities in the port of Assab and the Assab corridor.

Present capacities in the port of Assab are estimated at a minimum of 1,000 TPD, an average of 2,200 TPD and a maximum of 3,500 TPD for all (bulk and packed) goods unloaded from international shipping and loaded on trucks. The daily capacity depends on the nature of the material handled and is highest for grain (a peak, short term capacity is estimated at 5,000 TPD). The biggest bottleneck lies in loading/transporting capacities for trucks. Since there are only 100 trucks (each of 22 tons) available per day, an average capacity of the port is calculated at 2,200 TPD, equivalent to 0.7 million tpy.

A development project for the Assab port, at a cost of approximately US$ 72 million, has been proposed for implementation with assistance from the World Bank, African Development Bank and European Investment Bank. It is hoped that the project will be mutually acceptable to Eritrea and Ethiopia. The project does not include fertilizer stores. Unloading/transportation capacity at Assab is expected to rise to 1 million tpy by 2000 as a result of this project.

It is very difficult to estimate the capacity of the port of Massawa as it has been out of operation for almost 2 years. The Port of Djibouti, handling at the present about 10 per cent of goods unloaded to and from Ethiopia will be able to accomodate, by the year 2000, a maximum of 30 per cent of all Ethiopian goods, provided that the plan of improvements in the railway system will be complemented by new trucking capacity.

If development of a fertilizer industry in Ethiopia was delayed well beyond the year 2005, the Red Sea ports, and especially Assab, would face a great problem in unloading and dispatching 1.25 million tpy of fertilizer to central fertilizer stores. This volume is equivalent to 50 sea-going vessels a year calling at Assab, each with a capacity of 25,000 tons, to be unloaded in one week. It should also be noted that fertilizer should be given priority over grain on account its lower weight.

It is estimated, therefore, that access to the Red Sea ports and their unloading/dispatching facilities is the most important constraint in FERTIS development, especially as fertilizer is only effective if applied in a timely manner. In this connection, figure 5 illustrates annual fluctuations in fertilizer demand.

Transportation is a serious infrastructural constraint on those subsectors handling materials in bulk. The World Bank estimates that transport costs for marble produced by ELMICO in Wollega are Birr 520 per cubic meter (US$ 250) to the port of Assab. Transport costs will be a critical determinant of the economics of exploiting FERTIS raw materials and of the fertilizer system itself, which must deliver fertilizer to cropping areas. Transport costs also directly affect the competitiveness of any domestic fertilizer industry in the world market.

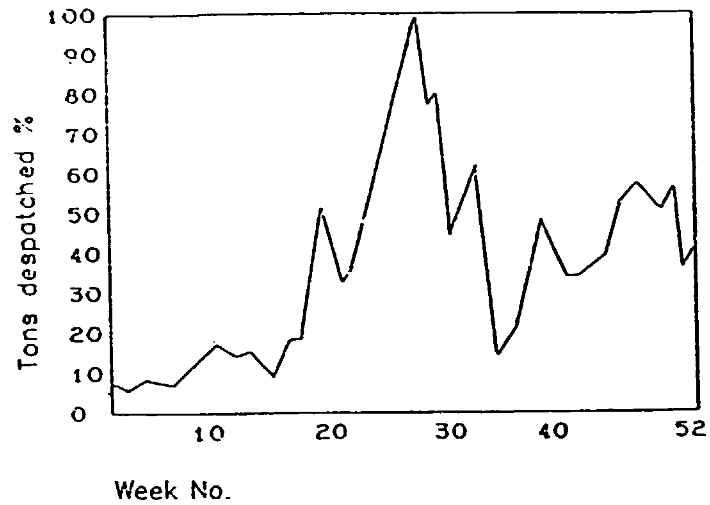
It is estimated by AISCO that the average total cost of handling 1 mt of fertilizer is as high as 288 Birr, or US $ 140. Of that, US $ 80 is spent on handling at the port of Assab and road transport to central warehouses in Nazreth, Mojo and Addis Ababa. For example, the CIF price of urea, purchased from the EEC in 1989 was 500 Birr (US $ 242) per mt of bagged product. The price of urea rose from 500 Birr CIF at the port of Assab, to 788 Birr per mt of bagged urea at the farm gate. The chain of port handling transport and storage operations thus causes a price increase per mt of bagged fertilizer of about 288 Birr (US $140), some 36 % of the farm gate price. The breakdown of this price increase is shown in Table 4.

Over 90% of fertilizers are distributed in surplus producing areas (figure 2), the remainder being shipped to potential surplus producing areas. Areas not producing an agricultural surplus are generally not supplied with fertilizers.

Fertilizers are distributed from AISCO's central stores in Nazreth, Mojo and Addis Ababa to about 750 Selling Distribution Centers managed by AISCO, from where fertilizers are sent to about 4,000 Service Cooperatives connected with some 20,000 Peasant Associations. There is no private distribution of fertilizers in Ethiopia at present. However, as privatization is a priority of the Transitional Government, private companies such as Ethiopia Amalgamated Ltd., which once dominated the procurement and handling of fertilizers, may re-enter this activity. From Service Cooperatives, that have a local fertilizer store, fertilizers are delivered to some 7 million peasant farms. A farmer usually buys from 1 to 8 bags (50 kg) of fertilizer product. The Ministry of State Farm Development (large scale farms) and Ministry of Coffee and Tea Development (cash crop producers) buy fertilizers from AISCO.

Figure 5

Typical Annual Demand Fluctuation



Bibliography Source: The Fertilizer Society of London: Packaging and Handling Fertilizers, 1970

The whole process of fertilizer supply and distribution, from request for fertilizer to its application, lasts approximately one year. About 7-8% of fertilizer is damaged during distribution, a fact of great concern to AISCO. Through a planned purchase of 50 truck-trailers, AISCO aimed to transport up to 50% of fertilizers distributed from central stores. Efficient procurement and distribution is an important part of plans of the Transitional Government of Ethiopia.

In Ethiopia's specific conditions, characterized by cumulative transportation constraints in a mountainous countryside, air transport could be utilized in special cases, both for spreading granulate fertilizers in the most remote areas, where road transport cannot supply fertilizer on time, and for deliveries of critical items of equipment for FERTIS construction sites.

(g) Consumption of fertilizers

This variable indicates both a considerable market in Ethiopia at about 100,000 mt of pure nutrients in 1989, as well as consumption growth of over 250% during the last decade. Including purchases of the Ministry of Coffee and Tea Development, about 170,000 mt of fertilizer products were imported in 1989 costing around US $ 44 million CIF. Similar figures relate to 1990 and 1991 (Table 2). Further rapid increases in consumption are expected by the end of the century, reaching an annual amount of at least 400,000 mt of NPK.

Table 4. The Build up in Price of One Imported Metric Ton of Fertilizer to the Farm Gate

(a) CIF port of Assab per mt of bagged urea	-500 Birr
(b) Product insurance (Assab-Nazareth of Addis Ababa)	- 3 Birr
(c) Bank charge (Letter of Credit)	- 21 Birr
(d) Port dues	- 1 Birr
(e) Transport and handling in the port (clearing charge) Maritime Transit Service Corporation	- 57 Birr
(f) Transport from Assab to warehouse in Nazareth or Addis Ababa (transit to warehouse)	-108 Birr
(g) Unloading in warehouse	- 3 Birr
(h) Loading on trucks	- 3 Birr
(i) Spoilage and losses	- 3 Birr
(j) Sub-total	- 690 Birr
(k) Overhead and general expenses (Bank, insurance)	- 30 Birr
(l) AISCO overhead	- 18 Birr
(m) Contingency	- 15 Birr
(n) Selling price before turnover tax	-753 Birr
(o) Turnover tax (2%)	- 15 Birr
(p) Selling price to Service Co-operative	-768 Birr
(q) Farm-gate price	-788 Birr

Defining the optimum future nutrients ratio is of great importance to FERTIS development (TA project 6). The N:P ratio is in part dictated by unit transport costs of fertilizer (DAP, 64% NP and urea, 46% N, are preferred). The average N:P ratio in the period 1985-1991 ranged from 1:1.38 to 1:1.84, the mean value being 1:1.59. FAO's former recommendations included an N:P ratio of 1:1 by the year 2000 (FAO 1989). FAO's latest assumptions of 1:0.72 have shifted even further to nitrogen (FAO 1991). The Institute of Agricultural Research (IAR) recommended a future N:P nutrient ratio of 1:0.5.

As discussed above, the N:P nutrients ratio of 1:1.5 is expected to shift towards nitrogen. An N:P ratio limit value of 1:0.5 may be expected by the year 2005. No secondary nutrients or micro-nutrients are known to have been used in 1989. The nutrients ratio of all fertilizers imported in 1989 was around 1:1.54:0.03 (N:P:K). Priority was given to DAP (75%), Urea (20%) and NPK fertilizers (5%).

Fertilizer prices in 1989 were relatively high, and the crop-fertilizer price ratio was low. Fertilizer was subsidized by 7% for the peasant sector. Small scale peasant farms accounted for over 75% of fertilizer consumption. In 1989 over 75% of fertilizer was consumed in 3 regions (Shewa, Arsi, Gojam), where some 15-20% of farmers use fertilizers. The rate of fertilizers adoption in the other 11 regions of Ethiopia was very low.

Large scale farms (total area about 200,000 ha) consumed around 15% of fertilizers in 1989. Large farms under the Ministry of State Farm Development share the cash crops market with the producers of coffee and tea under the Ministry of Coffee and Tea Development. This Ministry accounted for about 5% of nationally consumed fertilizer. Around 5% of fertilizer consumption was shared by other organizations, including resettlement programmes.

The largest share of fertilizer, over 80%, went to cereal crops, of which about half was applied to teff, followed by wheat, barley, maize and other crops. Extension services, supervised by the Ministry of Agriculture through the Agricultural Extension Department, are particularly important for increasing the rate of fertilizer adoption by farmers. Although extension services have been improved significantly in recent years, it is essential that they be sufficiently endowed with funds and staff so as to reach an increasing number of farmers, especially in the peasant sector.

(h) Demand for fertilizers by the year 2000 and beyond

One of the major issues in FERTIS development in Ethiopia is the need to estimate in a more precise way the size of NPK demand by the year 2000 and beyond. There are several contradictory estimates.

Projected demand for fertilizers by the year 2000 and beyond (the year 2005 has been chosen as representative of the period 2000 - 2010) is in the range of 400,000 mt to 650,000 mt of NPK. This comprises lower and upper limits as follows: An NPK low demand by the year 2000 of 400,000 tpy nutrients (700,000 tpy product), with an N:P of 1:1; a high NPK demand by 2000 and beyond of 650,000 tpy nutrients (1,340,000 tpy product), with an N:P of 1:0.5. This projection is used in the present programme with the amount of fertilizer product changed to 1,230,000 tpy as a consequence of differences in fertilizer imports.

The high projection, based on IAR estimations was recommended by UNIDO. The low demand figure corresponded broadly with the forecast adopted in the FAO study "Ethiopian Agriculture - Crop Yield Response and Fertilizer Policies" of July 1989. However, the latest FAO forecast of 1991 puts fertilizer demand in the year 2000 at 900,000 tpy of product, with an N:P ratio of 1:0.72, which is equivalent to 495,000 tpy of NPK.

In the market study for fertilizer demand, carried out by the National Chemicals Corpation (NCC) in January 1991, the estimated NPK demand 1990/91 varies from 241,000 tpy of NPK up to 681,000 tpy of NPK depending on the criteria chosen for estimations (especially changes in cultivated area).

Based on food self-sufficiency estimates, and an acreage of 7 million ha, the fertilizer demand 1990/1991 of 480,000 tpy NPK, projected by NCC to 2004/2005, gave a resulting demand of 656,000 tpy of NPK. The N:P ratio was kept constant throughout the study at 1:1.35.

One of the estimations in this study is the NFIU recommendation (for a cultivated area of 7 million ha) of 529,000 tpy of NPK (N:P = 1:1.35, and 890,000 tpy product). In this recommendation demand for fertilizer is driven by the acreage under cultivation. As can be seen from the above comparison, NPK demand in the year 2000 and beyond varies across a large range. This variation is most notable for the N:P ratio, which varies almost threefold, from 1:0.5 (IAR, UNIDO), through 1:0.72 (FAO), up to 1:1.35 (NFIU, NCC). Due to a very broad range of demand and N:P ratio estimates, it is suggested in this Integrated Programme that a seminar be held to further this discussion (TA project 6).

Given a similarity between NCC and UNIDO estimations of NPK demand in the year 2005, it was decided that only one estimate, of about 650,000 tpy of NPK, would be used throughout this report.

Present consumption of fertilizers is equivalent to 25% and 15 % of the demand for fertilizer in the year 2005 according to the low and high estimates respectively. These percentages indicate the extent of the required increases in fertilizer deliveries to agriculture. These increases will be severely constrained by storage, transport and distribution capacities (see section "f" above). Demand is highest for DAP and urea, but NPK is also sought, mostly for coffee farms. TSP is recommended for oil crops, where it may partly substitute for DAP. Sugar growers apply ammonium sulphate (AS) on alkaline soils. Nitrophosphates (NP) and CAN are also being tested for coffee. Cotton growers use urea. Urea is also used for coffee as a top dressing fertilizer, but is of limited use on acidic soils having no lime (limestone, dolomite). Present or future demand has not been defined for secondary nutrients S, Ca, and Mg, nor for micronutrients Bo, Zn, Fe, Cu, Mo, Mn, Co.

(i) Fertilizer application

Fertilization rates in 1989 were equal to 14 kg of NPK per ha of cultivated land, and 2 kg of NPK per capita. Table 5 compares projected fertilization rates for Ethiopia in the year 2000 with analogous figures for the World and Africa.

Table 5.

Projected Rates of Fertilizer Application in Ethiopia, the World and Africa

	NPK demand 2000 per ha of arable land with permanent crops	NPK demand 2000 per capita
World	145 kg	36 kg
Africa	38 kg	9 kg
Ethiopia (low estimate)	22 kg	6 kg
Ethiopia (high estimate)	36 kg *	9 kg *

* The low NPK demand estimate is 400,000 tpy. The high NPK estimate is 650,000 tpy.

Source: FAO 1981, 1986, 1988, and data from Ethiopia, 1989 (AISCO, MOA)

Arable land in the year 2000 is estimated at 18 million ha. The share of arable land in agricultural area is around 22%. Arable land per capita in the year 2000 is estimated at 0.28 ha, indicating a substantial growth in pressure on land resources. This is an enhancement for the development of the fertilizer industrial system, as it may increase the likelihood of more intensive agricultural development, especially as the assumptions relating to land resources are rather optimistic.

Of the estimated irrigable area of 2.4 million hectares only some 80,000 ha, or about 3 per cent, has been irrigated to date. Irrigation may in the distant future become a major enhancement for FERTIS development, especially through fertigation systems (fertilizer plus irrigation) on at least some 350,000 - 400,000 ha of arable land suitable for direct irrigation.

Rapid deforestation, erosion and desertification of arable land threatens the food the production base. It is noteworthy that according to most assumptions, including those of FAO and MOA, only about 6.0-9.0 million ha of arable land is expected to be cultivated by the year 2000.

For the high demand estimate, fertilization rates per ha of cultivated area in the year 2005, shown in Table 6, are very high when compared to the 1989 figure of 14 kg of NPK per ha of cultivated land.

Table 6.

Projected Rates of Fertilizer Application in Ethiopia by 2005

	NCC	UNIDO
NPK demand projected by 2005 (000 tpy of NPK)	650	650
Projection of cultivated land by 2005 (mln ha)	7.0	8.5
Projected fertilization rate per ha (kg NPK)	93	76

In order to keep data to a minimum, one projection of the growth of cultivated land is used throughout this report. This projection is shown in table 7.

Table 7

Projected Growth of Cultivated Land in Ethiopia to the Year 2010

	1989/91	1995	2000	2005	2010
Cultivated land (million ha)	7.0	7.5	8.0	8.5	9.0
Arable land with PC (million ha)	18.0	18.0	18.0	18.0	18.0

These figures do not ignore the downward trend of growth in cultivated area observed in recent years, but reflect consideration of Ethiopia's efforts to reverse this trend.

Application of DAP is expected to rise. However, with the increased residual phosphate content of soils, as a consequence of continuous phosphate fertilization, the importance of DAP will diminish, mostly in favour of urea. The application rate of urea is expected to grow constantly to the year 2000 and beyond.

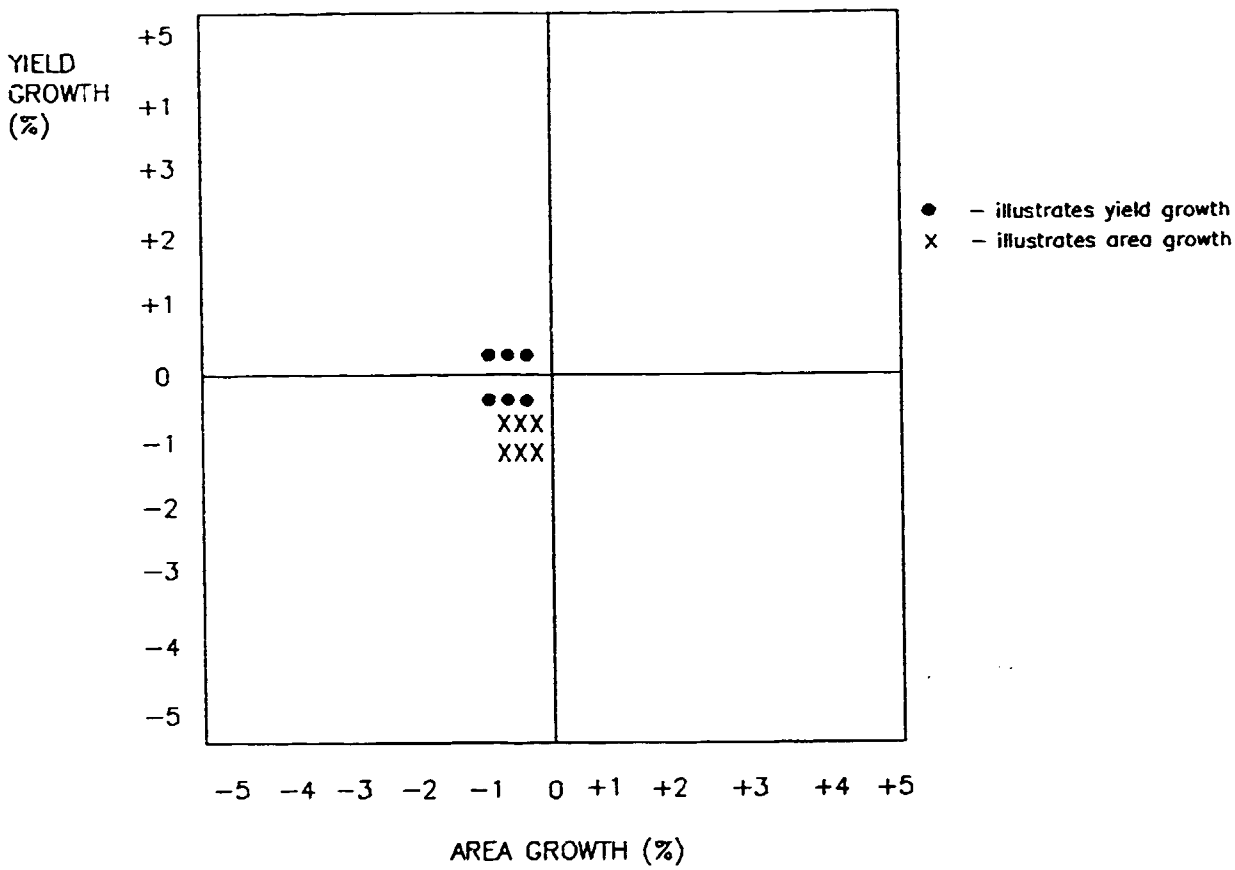
Amongst primary nutrients there is an expected trend from phosphate to nitrogen which will grow towards the year 2000. The N:P ratio is likely to shift from the present value of about 1:1.5 towards the ratios of 1:0.7 and 1:0.5 recommended by FAO and the IAR. Potash remains of lesser importance for Ethiopian soils. Secondary nutrients will be needed in the future to control the alkalinity and acidity of soils. Alkaline soils will have to be treated with fertilizers carrying sulphur, while acidic soils will have to be limed (limestone and dolomite carrying Ca and Mg). There will be a rising demand for the micronutrients Bo, Zn, Fe, Cu, Mo, Mn, Co which have a distinct influence on yield increases and plant growth.

(j) Fertilizer impact on agricultural production

Growth of cereal yields and arable area, shown in Figure 6, have not been promising in recent years. Most data for sub-Saharan Africa show positive

Figure 6

ESTIMATED ANNUAL GROWTH IN CEREAL YIELDS
AND ARABLE LAND AREA IN ETHIOPIA IN RECENT YEARS



Source: Interviews with IAR, NFIU, MOA

trends in area and/or cereal yield growth. However, as figure 6 shows, Ethiopia has experienced negative growth in arable land area and a negative tendency in cereal yield growth. Around 200,000 hectares are being lost per annum through erosion. Given serious constraints in the expansion of arable land, yield growth remains in practice the major source of crop production increases in Ethiopia.

According to FAO's "Agriculture Toward 2000", in the period 1982-2000 yield growth is expected to contribute 57% of crop production increases in sub-Saharan Africa, while arable land expansion and cropping intensity will add 26% and 17% respectively. Most opinion within the MOA indicated that the contribution of yield growth to increases in agricultural production in Ethiopia is expected to be about 80%, much higher than FAO's average for sub-Saharan Africa. Arable land expansion and increased cropping intensity are expected to contribute to crop production increases of about 10% only.

Improvement in crop yields through fertilizer use is described in the FAO fertilizer programme on maize in Ethiopia for 1967-78. Whereas average yields of maize were 1,050 kg per ha of cultivated area, yields achieved using fertilizer were 2,170 kg, with some yields as high as 3,280 kg of maize per ha of cultivated area. In best treatments an additional 16.3 kg of sorghum, 15.1 kg of maize and 7.3 kg of wheat could be grown per kilogram of NPK nutrients applied per hectare.

The NFIU has compiled a productivity index of cereals in Ethiopia (kg/ha of additional yield per kg of plant nutrient applied). The index for nitrogen and phosphate fertilizer are presented in Table 8:

Table 8.

Productivity index - Cereals Response to Nitrogen and Phosphate

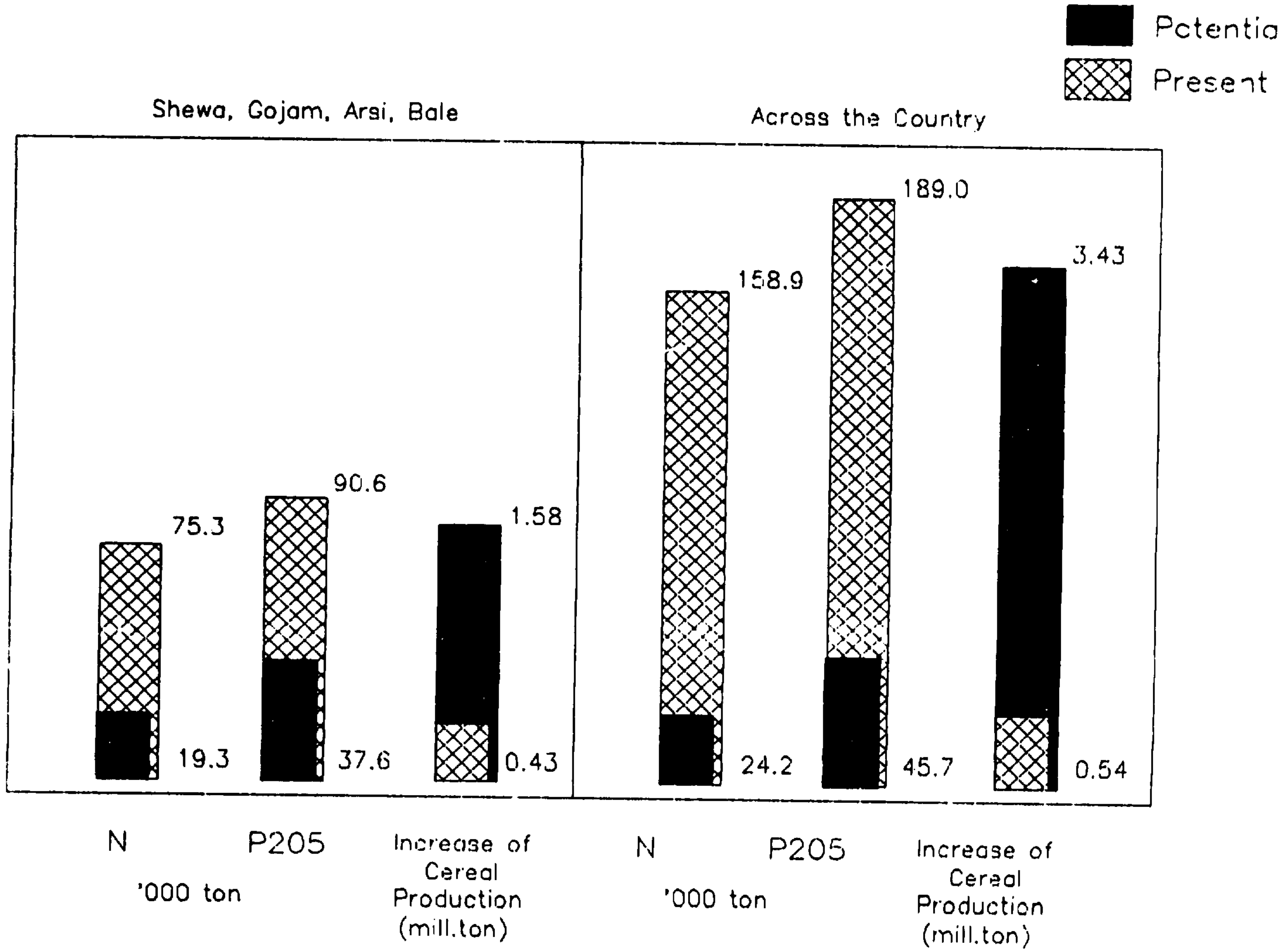
	N	P2O5
Teff	4 - 8	4 - 6
Wheat	7 - 13	8 - 14
Barley	3 - 8	10 - 14
Maize	10 - 22	11 - 22
Sorghum	8 - 15	9 - 14

Based on the present average productivity index of about 8 tons of cereals per ton of nutrients applied, NFIU proposed revised recommendations for application of fertilizer at the national level in 1990/91, aiming at a cereal yield increase of 3.4 million tpy. Cereal production and nutrient requirements according to these recommendations are shown in figure 7. Of note are the potential increase of cereal production due to planned increases of nutrients applied (up to 348,000 tpy of N+P2O5), and the dramatic shift towards nitrogen in the N:P ratio of fertilizer applied to cereals from 1:1.92 to the recommended 1:1.19.

According to the FAO study "Ethiopian Agriculture - Crop Yield Response and Fertilizer Policies" of July 1989 (no expansion of acreage scenario - Variant A), fertilizer consumption increases and proper policies may enhance food self-sufficiency and per capita dietary energy supply. It is held that the degree of self-sufficiency in cereals may be raised from 74% to 94% and dietary energy supply may increase from 1,618 to 2,001 kcal per capita per day if consumption of fertilizers in the year 2000 reaches 333,000 mt of NPK.

Figure 7

Cereal Production and Nutrient Requirement



Source: NFIU

(k) The Incentive to Use Fertilizers

Price and subsidy policies play an important role in stimulating agricultural production. The previously cited 1989 study on crop yield responses and fertilizer policies by FAO estimated that a fertilizer price subsidy of 50% would result in a 20% increase in fertilizer consumption. In 1989 fertilizers were subsidized by 7% for the peasant sector.

The average ratio of cereal to fertilizer nutrient price has fluctuated in the range of 0.38-0.18, with a slow decline during the years 1966-67 to 1986-87. The fall in the ratio from about 0.3 in the late 1970s to about 0.24 in the late 1980s has probably curtailed the use of fertilizers.

For most developing countries, with low fertilizer use and low crop yields, one ton of additional fertilizer nutrient ought to produce an extra 10 tons of cereal grain under favourable conditions, with the response diminishing as the application rate approaches the optimal level. In practice, the individual crop response to fertilizer and the final crop yield are the result of the interaction of a large number of factors. Some of these, such as climate, soil and yield potential of the plant material are largely beyond the control of the farmer. But many factors can be influenced, such as land preparation, crop variety, sowing date, control of weeds, diseases, pests, etc.

Figure 8 illustrates the sources of reduction in fertilizer efficiency which may be caused by controlable factors. It is worth noting that unbalanced fertilizer application may cause reduction in fertilizer efficiency in the range of 20 - 50%, underlining the importance of future recommendations on fertilizer types, grades and nutrient ratios at a national level and extension services at the farm level. The factors shown in figure 8, together with the crop/nutrient price ratio, constitute a combined risk to the farmer, who will only use more fertilizer if he is sure that the resulting benefits are considerably higher than the risk involved. Therefore, the package of incentives designed to increase fertilizer efficiency and adoption by farmers is of crucial importance.

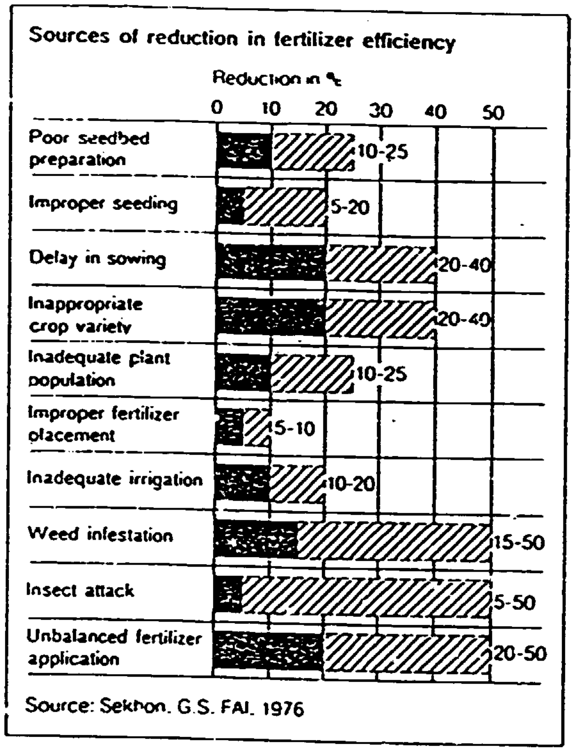
The percentage of farmers using fertilizer is likely to increase from about 10-15% to some 30% by the year 2000. Improved extension services, demonstration trials, timely and efficient distribution of fertilizers together with expansion of farm support services, appropriate subsidy and credit policies are essential for higher rates and efficiency of fertilizer use.

A new draft document on transitional economic policy ensures special attention and support to the peasant sector, including supply of fertilizers, improved seeds and enhanced incentives. Farmers are to have the right to full use of their produce, to sell their crops and buy commodities on the free market. Heavy taxes are to be lifted and made commensurate with land holdings and income. At the same time, expansion of private commercial farms is encouraged. State farms are to be reduced, sold or dismantled.

(l) Government priority in FERTIS

Though fertilizer is very costly, the Government allocates growing financial resources for imports of fertilizers, illustrating the importance accorded by the Government to the supply of this input. Plans to begin development of a national fertilizer industry are being seriously considered by the Transitional Government.

Figure 8



Bibliography Source: Fertilizer Strategies – Land and Water Development Series No. 10, FAO, 1987

Even more important is the fact that the Transitional Government included domestic production of fertilizers in the 1991 Industrial Policy Document as an area of vital importance to the economy. While limiting the role of the state, the Transitional Government has decided to focus its involvement on selected areas (mining and energy, major engineering and metal industries, pharmaceuticals, production of fertilizers, chemicals and producer goods).

The Government has attached great importance to timely and adequate supplies of fertilizers while co-operating with the World Bank and donor organizations on the preparation and appraisal of the Emergency Project, which includes an emergency input allocation for the purchase of fertilizers (about 200,000 tonnes in 1992/93).

According to many interviewed Ethiopian agriculture specialists, FERTIS is the input sub-system to which highest priority should be given (from amongst irrigation, agro-machinery, improved seeds, new crop varieties, pesticides, and fertilizers). The limited use of fertilizers is considered a key constraint on cereal yields and agricultural production increases, especially in the Ethiopian Highlands.

The following order of priority of inputs, lack of which restricts cereal production increases in the Highlands, seems to be the most frequently shared among Ethiopian specialists: 1. Fertilizers; 2. Seeds and improved crop varieties; 3. Agro-machinery; 4. Pesticides, and 5. Irrigation.

Some specialists pointed to the timing of fertilizer application as the critical factor for fertilizer effectiveness, giving higher priority to the agro-machinery system. Food preservation systems were also highly ranked when cereals were discussed. It should be noted that different opinions exist on the order of priority as far as lowland or cash crops (cotton, coffee, sugar cane, oil crops) were concerned, with FERTIS usually not given the first order of priority here. The following order of priority among inputs for the lowlands was common: 1. Seeds; 2. Pesticides; 3. agricultural machinery, and 4. fertilizers. For cotton the order of priority was: 1. Irrigation; 2. Pesticides; 3. Seeds; 4. agricultural machinery, and 5. fertilizers.

1.2 Government Development Objectives Related to the FERTIS

With political changes and a new economic policy, existing development plans and strategies will be revised in the transitional period of 2-2.5 years. However, general development objectives of the Transitional Government are aimed at food self-sufficiency and a greater market orientation for the economy.

Agriculture is the sector given first priority, with primary emphasis on development of the peasant sector. Government will also concentrate on the export of coffee.

The second priority area is industrialization, with associated development of the energy and mining sectors. Mining and energy policy aims at implementation of already prepared projects, as in natural gas development, for example, and acceleration of actions and studies aimed at long-term development of mines and energy.

One of the broad policy directions of the Transitional Government is to mobilize greater external assistance. Foreign investors are to be encouraged and technology transfer is to be promoted. In the light of the above, there is no doubt that the Transitional Government will, in revised development plans, give high priority to sustainable development of the FERTIS. However, detailed objectives relating to the FERTIS had not been prepared at the time this Integrated Progamme was drafted. It may thus be useful to review the most important FERTIS development objectives of the previous Government, allowing that these may be changed in new development plans.

The Ten-Year Perspective Plan 1984-85 to 1993-94 was the most important statement on the development of the economy. A prime objective of the Ten-Year Perspective Plan was to accelerate growth of the economy through expansion of agriculture, mining and industry. Attainment of food self-sufficiency and a minimum three month food reserve were the most important of the plan objectives.

To promote inter-sectoral linkages, particularly between agriculture, mining and industry, the plan sought to promote import substitution based on national resources. Industry would commence production of fertilizers in order to meet at least part of the requirements of agriculture. In a similar manner the mining sector would produce, inter alia, potash and limestone.

The sector plan for agriculture envisaged importing fertilizers in greater quantities, while agricultural research was to be directed towards raising the yield of indigenous crops through improved fertilizer application.

One objective - now an example of over-optimistic planning - was domestic fertilizer production of 270,000 mt by 1993-94, with an estimated value of 386 million Birr. It is now assumed that domestic production of fertilizer may only begin in 1998. Projects were planned for primary nutrients (NPK), and to a lesser extent secondary nutrients (S, Ca, Mg).

Strategies for the mining sector gave priority to petroleum and natural gas exploration. Potash development had been given priority in investment for the mineral sub-sector as this activity was oriented towards both domestic and export markets.

Developments in transport were related directly to FERTIS operations. The following were the major projects in the transport sector for the ten-year plan period:

- Improvement of Addis Ababa - Djibouti Railway line;
- Acquisition of locomotives and wagons;
- Acquisition of buses and trucks;
- Expansion of Assab and Massawa ports.
- Addis Ababa - Assab Railway line construction;

Some of these projects, such as the first three, are likely to be incorporated in the new development plans. Others, especially the last one, will perhaps be subject to more detailed investigation. Plans to construct, with EEC assistance, a fertilizer store in Assab with a capacity of 25,000 mt of bagged fertilizers, are likely to be postponed.

1.2.1 Plans for Specific Investments in FERTIS Plants

Plans for an Ammonia-urea Complex at Gode

Plans to establish an A/U mini-fertilizer plant at Gode have been modified (scaling-up capacities) and accelerated, while plans for a world-scale A/U complex at Metahara appear to have been abandoned.

The nitrogen fertilizer complex at Gode envisages capacities of 450 TPD ammonia, 765 TPD urea (later referred to as 500 TPD A + 800 TPD U). With a high nitrogen demand (up to 279,000 tpy according to the Government programme), the decision to increase nominal capacities of the A/U complex was fully justified. The following factors are among the major merits of the A/U project at Gode:

- A well selected capacity and process for the ammonia plant (Leading Concept Ammonia process, proven industrially by ICI);

- A minimization of the capital investment cost (natural gas pipeline plus A/U complex) through location of the complex at Gode, some 100 kms from the natural gas well-head at Calub.

- A low ex-factory urea manufacturing cost.

- An advanced stage of preparation of the project, for which feasibility work was done by the International Fertilizer Development Center.

- Any negative impact of the A/U complex on the environment may be less significant in this location.

- The development impact on the Ogaden Autonomous Region, which has until now received insufficient support in national plans.

However, this project is expected to supply only some 40 per cent of the demand for nitrogen by the year 2005, the balance coming from grants or commercial being imported (or grants) or produced through another nitrogen or nitrogen-phosphate fertilizer project. A further drawback of this project is its non-optimal location for urea distribution in cereal producing highland areas. The location at Gode almost totally excludes the option of locating a second A/U complex in the cropping area (Yirga Alem), since there would be no justification for connecting the natural gas field with the highlands by a long pipeline.

Plans for a DAP (TSP) versatile plant in Assab

Plans for the establishment of a phosphate fertilizer complex at Assab, based on imported ammonia and phosphoric acid (and phosphate rock), have been abandoned due to the unfavourable relation of prices between the above mentioned intermediates and DAP (TSP). This decision is justified for economic reasons, and because of uncertain access to Assab.

However, with fertilizer demand by the year 2005 as high as 656,000 tpy of NPK, and with an N:P:K ratio of 1:1.35:0 adopted in the national plans, the shortfall in phosphate fertilizers will be as high as 377,000 tpy of P2O5, and should be addressed as soon as possible. Ethiopia is likely to face a considerable dependency on imports (grants) of phosphate fertilizers.

Plans for a Potash fertilizer complex at Dallol

No progress has been reported on plans for an export oriented potash fertilizer complex based on domestic potash ore since 1989. A number of factors lead to the recommendation here that this export oriented project should be preceded by a pilot-scale industrial production aimed at satisfying domestic demand in the range of 20,000 - 25,000 tpy of K2O, before industrial scale production for export. These factors include the following: the huge investment required; growing delays in exploration of the potash deposit under an Ethiopia-Libya joint-venture agreement, and overcapacity and low potash prices on the world potash market.

1.3 Ongoing Development Activities Related to the FERTIS

With the advent of the new Government and a new economic policy, it is difficult to predict the evolution of ongoing development activities related to the FERTIS. Some may be accelerated, and others suspended or abandoned. Due to changes in the USSR and the former Eastern Bloc, some previously initiated activities may not be given support at the present time either by the East European countries involved, or by Ethiopia itself.

Around US$ 500 million is being proposed, through the World Bank, for the Emergency Recovery and Reconstruction Project in Ethiopia for 1992. An emergency inputs allocation of US$ 86 million would be used largely for purchases of fertilizer.

Activities likely to be least affected by the change of Government are those undertaken with the assistance of the World Bank Group and the African Development Bank (ADB). Some of the most important activities directly or indirectly related to the FERTIS undertaken in recent years by the IDA, the ADB and the previous Government under its Public Investment Programme (PIP) are listed below:

1.3.1 Agriculture and rural development (IDA) - US$118.6 million

PADEP I - (IDA) - US$ 85 million

Support for the government's reform-minded agricultural development programme (PADEP I), which has considerably liberalized grain marketing, will help to improve the incentive framework, facilitate the production response among peasants, and mobilize support from other donors.

Coffee Development (IDA) - US$ 35 million

The project would strengthen Government support services for food and coffee production in the major coffee producing areas. Support would also be given to expanding washed coffee primary processing facilities, rehabilitating coffee hulleries and improving export processing facilities.

Small Scale Irrigation (IDA) - US$ 7 million

Problems caused by frequent drought and increasing desertification will be addressed through construction of small-scale irrigation schemes in drought affected areas together with conservation and agricultural support in the Hararhge region. Co-financing is anticipated from the International Fund for Agricultural Development (IFAD) (US $ 12 million), the Organisation of Petroleum Exporting Countries (OPEC) (US $ 4 million), and the World Food Programme (WFP) (US $ 1 million). Total cost: US$33.7 million.

Agricultural Research (IDA) - US$ 22 million

1.3.2 Transportation (IDA) - US$ 72 million

The turn around time of cargo ships will be diminished by ameliorating bottlenecks in the port of Assab, freight forwarding, customs, and road transport, particularly from Assab to Addis Ababa. Co-financing is anticipated from the African Development Bank (US $ 55 million) and the European Investment Bank (US $ 12.5 million). Total cost: US $ 164.6 million.

1.3.3 Mining and Energy (IDA)- approximately US$ 55 million

This programme has five major elements:

(i) Power transmission and distribution

(ii) Small-scale gas utilization
(iii) Rehabilitation, modernization and expansion of Assab oil refinery
(iv) Petroleum exploration promotion
(v) Mining sector development

1.3.4 African Development Bank - Different FERTIS related projects

No details are available on the ADB projects. However, the ADB has an important involvement in activities relating to the FERTIS, in coffee schemes, Assab port development, agriculture and rural development, irrigation, road maintenance and rehabilitation, hydro-energy and water supply.

Of particular importance to FERTIS development is a Bikilal Phosphate Exploration Study, considered in 1992 -94 ADB lending programme. This is yet to be agreed with the Government.

1.3.5 The Public Investment Program (PIP)

It should be borne in mind here that priorities expressed in the PIP of the previous Government may change.

(a) Transportation

Key issues addressed by the PIP were; the limited berthing capacity of ports, old and inadequate cargo handling equipment, an old and limited trucking fleet, insufficient rail capacity required to move goods inland from the Port of Djibouti, and a striking lack of roads (both primary and rural) throughout the country. Investment expenditures were to be distributed as follows; road transport equipment (224.3 million Birr); railways (113 million Birr); ports and shipping (173.1 million Birr), and road construction (511 million Birr). It should be noted that the former Government was unable to mobilize necessary resources for the Addis Ababa to Assab railway project. This project would be of great importance to FERTIS development through the transport of imported fertilizers to central stores.

(b) Industry

The PIP allocated about 125 million Birr to the chemical sub-sector, including six projects. These projects did not appear to have been adequately prepared and appraised and implementation was unlikely. A number of projects and fora existed involving international co-operation with former Communist countries in areas related to the FERTIS, although political changes are likely to curtail these activities.

1.3.6 Agricultural and Industrial Development Bank (AIDB)

Ongoing activities related to FERTIS development also included loans and credits approved by the AIDB. Loans approved in 1987 to agriculture, industry and other sectors amounted to 400 million Birr, 25 million Birr and 74 million Birr respectively.

1.4 Institutional Framework for the Development of the system

(a) General background

Establishing a domestic fertilizer industry is a multi-faceted task requiring an efficient institutional context. This Programme for the Integrated Development of the FERTIS has as one of its aims the strengthening of national capabilities in programming and coordination of balanced development in the fertilizer industrial sub-sector, investment planning, technology selection, procurement, trading and logistics, and training.

As described later in Section 4.2, twenty technical assistance projects in different sectors of the economy make up this Integrated Development Programme. Projects 1, 2, 3, 4, and 10 relate to the institutional framework and areas of policy concern.

In order to facilitate implementation of the Integrated Development Programme it is suggested that an inter-sectoral co-ordinating body (Steering Commitee) be established. A Steering Commitee located in the Ministry of Industry, should include representatives from planning, agriculture, industry, mining, energy, water resources, environment, construction, trade, transport, manpower, and finance sectors. Among other tasks, the proposed Steering Commitee would be responsible for:

- supervision of the development of the system according to the programme schedule, including preparation and timely implementation of the TA projects located on the critical path of the programme;

- assuring adequate provision and priority in medium and long-term national investment plans for the requirements of the fertilizer sub-sector;

- mobilizing external assistance for the programme (the World Bank, ADB, UNDP, donor organizations, international financing institutions and specialized organizations such as IFDC, FAO and UNIDO). TA project 2 relates to this function;

- establishing a mechanism for effective transfer and development of fertilizer production technologies, through building technology absorption capabilities, training, establishing a technological information documentation and exchange system, as well as encouraging research and development activities;

- taking decisions on temporary subsidies for prices of raw materials and energy (natural gas and hydroelectric power) as against subsidies on fertilizer prices, to reduce the price of fertilizers to a level attainable by most peasant farmers. This function is of particular importance in the period when the fertilizer industry will carry the burden of repaying its investment credits;

Extension Services

Extension services are an important part of the institutional context related to the FERTIS, and are particularly important for increasing the rate of fertilizer adoption by farmers. Extension services are supervised by the Ministry of Agriculture through the Agricultural Extension Department. In each of the 30 provinces (administrative regions) and 107 districts there are Heads, Group Leaders and Subject Matter Specialists (SMS) who supervise extension services.

In each district the SMS supervises Development Agents (DA) who work with Contact Farmers and reach, through Follower Farmers, about 5 million peasants in surplus producing areas. DAs operate in 1,607 Development Centers bringing extension information every 15 days to over 79,000 Contact Farmers throughout Ethiopia. The average ratio of DAs to farmers is 1:1,300.

Although extension services have improved significantly in recent years, it is essential that they be sufficiently endowed with funds and staff so as to reach an increasing number of farmers, especially in the peasant sector.

1.5 Areas of Policy Concern

The development of a FERTIS requires complex policy support. To facilitate implementation of this Integrated Development Programme a number of policy issues should be studied in detail. The most important policy issues are listed below:

(a) Policies affecting the peasant farmers' access to:

- technology (fertilizers, seeds, pesticides, etc.)
- agricultural extension and advisory services
- rural infrastructure support, especially access roads, storage facilities, marketing centers, etc.

Access to industrial inputs and services is a central constraint on Ethiopian agriculture, especially as agricultural credit has, in principle, not been as severe a problem to the farmer as absorption of technology.

(b) Pricing and subsidy policy on fertilizer raw materials, fertilizer and crops.

Pricing and subsidy policies formulated to stimulate fertilizer use are of key importance in halting the decline in per capita food production of the last two decades. These policies also affect the financial viability of a domestic fertilizer industry, especially in the early stage of development.

(c) Policies related to technology transfer and development:

- technology transfer and absorption capability in the FERTIS, and associated research and development.
- training in technology information collection and exchange within industry.

(d) Policies related to import substitution and export promotion strategies in FERTIS.

(e) Investment related policy issues to strengthen capabilities in the purchase of technologies and equipment for a domestic fertilizer industry (technical norms and standards, environmental protection standards, etc.).

(f) Sectoral and subsectoral policies in agriculture, industry, mining, energy, water resources, construction, trade, transport and manpower.

(g) Environmental protection and appropriate utilization of natural resources.

Of great importance under (g) are the policies on soil conservation, protection of the air and water from fertilizer pollution, exploration of FERTIS raw materials and pollution-free operation of fertilizer plants and complexes.

The World Bank has expressed support for the following policies related to the FERTIS: Involvement of the private sector in the retailing of fertilizer; increased availability of credit to farmers, and liberalization of the economy, allowing private sector investment in FERTIS related projects.

This Integrated Development Programme contains five projects directly related to policy and plan formulation. These are detailed in section 4.2.

2. PROGRAMME JUSTIFICATION

2.1 Problems to be Addressed: Bottlenecks and Constraints Hindering the Development of the System Towards the Government Objectives

This section should be read in conjunction with section 1.1.4 describing the components of the Ethiopian FERTIS. The main problems that negatively influence FERTIS development are the following:

(i) Inadequate exploitation of the raw material base, especially for phosphate and sulphur. This constraint exists for a number of reasons. For example, the Ogaden region, the site of recent natural gas discoveries, is characterized by relatively poor general infrastructure.

At the same time, intensive surveys and exploration of domestic resources such as phosphate rock (apatite) and sulphur (pyrite) are of great importance in decreasing dependency on imported phosphate fertilizers. This is especially so as the potential phosphate and sulphur raw material base is less well known than that for nitrogen and potassium.

Regional conflict halted feasibility work on exploiting potash ores. Continuous research on a pilot-scale facility is necessary.

Since acidic soils are located mostly in western regions of the country, logistical and transportation constraints hinder exploitation of the many limestone-dolomite deposits located in eastern regions. Surveying and prospecting for micronutrients (Bo, Zn, Fe, Cu, Mn, Mo, Co) should be initiated in the near future.

(ii) Transport related constraints. These include an uncertain future access to the Red Sea coast and its principal ports (Assab, Djibouti and Massawa), making difficult any long-term decisions involving supplies of FERTIS raw materials, intermediates and final products from the international market.

Transport bottlenecks include inadequate or non-existant unloading facilities in ports, especially at Assab from where all purchased fertilizers are transported to central fertilizer stores in Nazreth, Mojo and Addis Ababa.

A relatively weak transport network in the countryside results in limited access to fertilizers, even in surplus producing areas. Poor fertilizer distribution raises prices, aggravating the low crop/fertilizer price ratio and thus diminishing the incentive to use fertilizer. Inadequate transport infrastructure affects both the timing and price of supplies of inputs to agriculture as well as the movement of agricultural exports.

A shortage of trucks and wagons increases delays in handling and contributes to damage caused to fertilizer during distribution.

Insufficient storage capacity. This again increases delays in handling and contributes to damage to fertilizer during distribution. Approximately 7-8% of fertilizer is damaged during distribution. On average around one year elapses between an application for fertilizer and its supply.

(iii) Progressive degradation of arable land, resulting in losses of cultivable area. This is a serious constraint to FERTIS development because of the reduction in acreage of land suitable for fertilization.

(iv) Shortages of water in many regions and limited finance for expansion of irrigation. Fertilizer is a vital component of an improved crop technology package. However, it is only when the water constraint is released that other technical constraints such as nutrient availability become important.

(v) Insufficient awareness of optimum N:P:K nutrient ratio and of the types of fertilizers to be used. This perpetuates inefficient fertilizer application and hinders rational production planning and long-term strategy formulation in FERTIS development.

(vi) Low incentives for fertilizer use. This is due to low prices for agricultural produce compared with prices of fertilizer, a lack of subsidies, and inadequate extension services. The absence of pricing policies formulated to increase incentives for fertilizer use have contributed to the decline in per capita food production of the last two decades.

(vii) Insufficient extension services. This acts as an important factor limiting fertilizer use. This is all the more a constraint on Ethiopian agriculture as agricultural credit has not been as severe a problem to the farmer as absorption of technology and access to industrial inputs and services (improved agricultural methods, extension and advisory services, fertilizer storage and handling facilities, infrastructure).

(ix) A lack of experience in investment, operation and maintenance of chemical plants and complexes.

(x) Environmental constraints on FERTIS development. These include fertilizer leaching from the soil, contamination of underground waters, and restrictions on the location of FERTIS facilities in some areas either because of existing wildlife and unique habitats, or because of the danger of increased pollution (existing fluorine contamination of drinking waters in the Rift Valley may be worsened if phosphate fertilizer plants are built in this area).

(xi) Limited foreign exchange resources for implementation of technical assistance projects and investments relating to FERTIS.

Table 9 outlines the main system constraints, the components of the FERTIS affected by each constraint, and ongoing and planned activities relating to each constraint.

2.2 Major Enhancements to FERTIS Development in Ethiopia

The following factors would support development of a FERTIS in Ethiopia:

(i) A strong nitrogen and potassium raw material base. This includes proven deposits of 78 billion cubic meters of high quality, sulphur-free, high presssure natural gas, and a high quality potash deposit equivalent to 10-18 million mt of recoverable KCl. This srong nitrogen/potassium

Table 9: System Components, Constraints and Ongoing/Planned Actions

Component	Constraint	Ongoing/Planned Actions
A. Natural Resources		
Natural gas utilization	Natural gas field located in remote area. Lack of funding for NG development.	Government considering NG small-scale and large-scale utilization schemes.
Water, hydroelectricity	High cost of water electrolysis to ammonia	Hydroelectricity expansion schemes by 2010
Phosphate and sulphur R.M.	Limited development of mining sector.Lack of finance for feasibility studies.	IDA support in mining sector development
Potash ores in Danakill	Delayed feasibility studies. Huge capital necessary for export oriented production.	Major activities suspended since 1986/87.
Secondary nutrients and micronutrients	Limited development of mining sector and awareness of benefits from their use.	Preliminary work carried out by EIGS.
B. Processing to Intermediates	Ammonia, phosphoric and nitric acids not yet manufactured. Sulphuric acid plant of small capacity being implemented.	Small sulphuric acid plant being built for production of aluminium sulphate plant for water treatment. Plan exists for A/U/NA complex at Gode.
C. Processing of NPK fertilizers	Not yet developed, despite many previous plans, however not given full support.	Plans for A/U complex at Gode. Plans related to MOP/SOP complex suspended.
D. Other operations	There is no bulk blending unit in Ethiopia. Only bagged fertilizer is imported.	Plans for construction of a fertilizer store in Assab suspended.
E. Energy self-sufficiency and per capity energy consumption	Despite abundant energy potential (hydro and geothermal) and huge gas deposits, low level of development of energy sector causes deforestation (fuel gathering) thus aggravating soil erosion.	Strong ADB support for developing hydro-electricity schemes but not for FERTIS. Support from UNDP, EEC and Italy given for utilization of geothermal potential but not for FERTIS. IDA support for energy sector. NG utilization promoted by WB but not for FERTIS. Seven oil blocks at Red Sea coast offered to western companies.

Table 9 (contd.)

F. Storage, transport and distribution	Limited access to Red Sea ports. Inadequate storage facilities at Assab port and in Ethiopia itself. Poor quality roads and insuffficent road network cause delays in fertilizer supply and product damage during distribution.	Upgrading of Assab port and various road improvement schemes are considered by the Wrold Bank, ADB, EIB. Nearly a quarter of allocation for an Emergency Project in Ethiopia for 1992 (total USD 500 million) is to go to renovation of infrastructure. Emergency project is administered by World Bank (IDA), EEC, ADB and donor countries.
G. Consumption of fertilizer	Consumption of fertilizer limited because of inappropriate crop/nutrient ration, low rate of fertilizer adoption by farmers, inadequate extension services and limited distribution capacities. Infrastructure forces use of only DAP and urea (the most concentrated fertilizers). No secondaries or micronutrients are being used.	Eight-fold increase in fertilizer consumption planned in Ten-Year Perspective Plan. Imports/grants of fertilizer kept at about same level since 1989. DAP and urea are only types procured and consumed.
H. Demand for fertilizer in 2005	There are several different estimates on optimum fertilizer depand and N:P:K ratio by 2005. Fertilizer demand is expected to grow sixfold to assure nation's food self-sufficiency. This volume will be severely constrained by access to Red Sea ports and their unloading/reloading capacities.	Liberalization of crop prices and increase in crop/fertilizer ratio is expected to stimulate fertilizer demand. Plans for irrigation systems and cultivated land expansion as well as extension services are expected to increase fertilizer adoption rate by farmers. Access to port of assab depends on referendum on Eritrea.
I. Fertilizer application	Only DAP and urea are being used at present. Complex NPK fertilizers, secondary nutrients and micronutrients will have to be applied if yields are to grow substantially by 2005.	Research on fertilizer applications carried out by IAR, NFIU, FAO in close cooperatoin with MOA. Extension services being improved by MOA. Priority is given to a peasant sector in 1992.

Table 9 (contd.)

J. Fertilizer impact on agricultural production	Limited FERTIS development is a severe constraint to increases in crop yields and agricultural production. Limited inputs to agriculture and soil erosion threatens food base of future populations in Ethiopia	ADB, IDA, IFAD OPE and WFP giving support to small-scale irrigation schemes ard agricultural development. FERTIS reckoned to be one of most important input sub-systems to agriculture. Emergency input allocation from IDA secure over USD 40 million for fertilizer purchases in 1992.
K. Incentive to farmers to use fertilizers	Inadequate crop to fertilizer price ratio. Lack of subsidy on fertilizers and risk in applying fertilizers by farmers. Insufficient awareness of benefits from proper use of fertilizers as well as misuse of fertilizers.	Transitional Government's policy aims at the privatisation of the economy, liberalisation of prices, improved farmers' access to credits, agricultural inputs, instead of former priority given to ineffective state farms.
L. Government priority in FERTIS	Insufficient information for appropriate policy formulation in FERTIS development.	Transitional Government's policy includes fertilizer sub-sector on a list of priorities to be given speical support from the state.

environment indicates that priority should be attached to the nitrogen and potash fertilizer industry in Ethiopia, as is the case in this Integrated Programme.

(ii) A large hydroelectric and geothermal energy potential that can be used for FERTIS development together with solar energy. Only about 10% of the huge hydroelectric potential, estimated at at least 60,000 GWh per year, will be utilized by the year 2005. This is despite the large investment in hydropower plants with a total generation capacity of over 1000 MW. There is also a very large geothermal energy potential, assessed at at least 3000 MW (Annex 1). This energy potential offers an important support to the establishment of a domestic fertilizer industry competitive in international markets.

(iii) Substantial potential for increases in irrigated area. The total potential is estimated at 2.4 million hectares. This offers the possibility of developing fertigation schemes (fertilizer application with irrigation).

(iv) Increasing pressure on cropland and limited carrying capacity of land suitable for agricultural production. These problems are caused by population growth, almost total deforestation and severe erosion of the soil. With limited potential land resources, FERTIS development assumes greater importance.

(v) Potential for improvement of extension services, facilitating increases in fertilizer use by farmers.

(vi) Relatively well developed air transport, which may be used to spread granulated fertilizer from the air in remote areas, where fertilizer cannot be delivered on time by road, as well as in transporting critical equipment to FERTIS construction sites (Annex 2).

(vii) Underutilization of capacities in metal and engineering industries. These industries may contribute to the manufacture of simple equipment for domestic fertilizer plants.

2.3 Strategy Considerations in National FERTIS Development

Two major issues of FERTIS development require strategy choices by Ethiopian policy makers and relate to the justification for establishment of a domestic fertilizer industry. These two issues are as follows:

1. Gradual long-term substitution of food aid by aid in fertilizers; and,

2. Fertilizer import substitution through development of a domestic nitrogen and phosphate fertilizer industry.

These strategy concerns can be assessed in general terms according to their contribution in achieving one or both of the following objectives:

A. Increases of cereal production aimed at reducing malnutrition and enhancing food self-sufficiency.

B. Generation or saving of foreign exchange, through increased exports of coffee and other cash crops by increased fertilization of these crops, through exports of potash or through efficient import substitution of food and/or fertilizer.

Strategy choices 1 and 2 are discussed below in terms of objectives A and B.

2.3.1 Benefits from Importing Fertilizer Rather than Food

This section attempts to illustrate the benefits of importing fertilizer rather than food. By clarifying this issue it becomes evident that the major remaining general strategy decision is that of selective FERTIS import substitution.

With a 1400-1630 kcal/cap/day Dietary Energy Supply (DES), reported by FAO as average for 1984-86, it may be assumed that a majority of the population faced malnutrition in that period. This DES is below the critical minimum intake of 1765 kcal/cap/day, and far below the average standard requirement set by FAO of 2092 kcal/cap/day.

Cereals (of which teff is the most important) account for 90% of food consumed. One kilogramme of teff provides 3450 kcal. To secure the standard calorie requirement, yearly cereal intake must reach 199 kg per capita.

Hence, to avoid widespread malnutrition as much as 200 kg of grain per capita per year ought to be supplied to at least 5 million Ethiopians (it is estimated that in recent years around 5 million people have faced severe food shortages). This implies the need for immediate emergency supplies of cereals of at least 1 million tons per year. With a mid-1990 population estimated at 51 million, the present national requirements for grain may be calculated at 10.2 million tpy (0.2 t/capita x 51 million).

Ethiopia's maximum current cereals production is estimated at 6 million tpy, or about 60% of the nation's grain requirements. Thus, in terms of standard calorie requirements, the present shortfall in domestic cereals production is equal to about 4.2 million tpy. This shortfall would increase dramatically by the years 2000 to about 7.2 million tpy in the absence of complex measures aimed at increasing production of cereals. In the year 2010 the shortfall would be 9.6 million tpy of grain.

Given a very limited potential for arable land expansion or increased cropping intensity, growth in cereal yields will have to contribute most to increases in agricultural production. In this regard it should be noted that fertilizer is one of the most critical inputs determining cereal yields.

Calculations based on work by FAO (1989) show that by applying 320,000 tpy of fertilizer nutrient it would be possible to obtain additional production of 2.45 million tpy of cereals (813,000 tpy teff and 1,637,000 tpy maize).

A weight ratio of 7.7 t of cereals per 1 t of applied fertilizer nutrient may be assumed (4.2 t of cereals per 1 t of DAP+U product). Thus, in terms of the weight of either imported fertilizer or food, and given serious handling and transportation constraints, deliveries of fertilizers (imports/aid) would be a better long-term alternative than deliveries of cereals (imports/aid).

In value terms, supplies of 2.45 million t of cereals are worth US $ 335 million. Alternatively, 320,000 t of fertilizer nutrient are worth only US $ 192 million. Thus for donor countries fertilizer aid rather than food aid, may optimize the impact of foreign assistance resources.

Given the scarcity of foreign exchange for imports of food and fertilizers, and bearing in mind possible limitations on international aid, it may be concluded that the supply of fertilizers (imports/aid) is a more justified long-term alternative for Ethiopia than supplies (imports/aid) of cereals.

Having illustrated the advantage of receiving fertilizers (imports/aid) as against cereals (imports/aid) possible import substituting projects should compare landed costs of fertilizers purchased in the international market and delivered to the cropping areas with the costs of domestically manufactured fertilizers delivered to the same cropping areas.

2.3.2 Potential Benefits of FERTIS Development

In addition to import substitution of fertilizers, which forms the basis of this Integrated Programme, other potential benefits of FERTIS development can be identified. These benefits are outlined below.

Coffee Production and Export Expansion

The second main objective against which fertilizer development can be compared is growth in foreign exchange earnings/savings. In this regard it should be noted that coffee exports are hampered by a shortage of fertilizer. Coffee is Ethiopia's principal export. Nevertheless, the rate of fertilization of coffee is low. Calculations using data from the Ministry of Coffee and Tea Development lead to the conclusion that proper fertilization of arable land under coffee could generate an additional US $ 95 million per annum, approximately, by the year 2000. These benefits further justify a strategy of increased supplies of fertilizers in Ethiopia, as illustrated in Table 10. In table 10 the quantities of fertilizer consumed refer only to coffee. High coffee export prices and nutrient import prices were assumed for the year 2000 of US $ 3040 per mt of coffee and US $ 675 per mt of NPK.

Table 10: Contribution of the FERTIS to Increased Exports of Coffee

Basic data	Without Fertilizer 1990	2000		With Fertilizer 1990	2000	
Arable land under coffee (ha)		281000	225000		41000	197000
Coffee yield (ton/ha A.L.)	0.472	0.5		0.6	0.7	
Coffee production (000 tons)	132.54	112.5		24.6	137.76	
Coffee price (FOB US$/ton)	3040	3040		3040	3040	
Coffee exports (miillion US$)	402.93	342.01		74.79	418.8	
Fertil. consumed (000 tons)	zero	zero		11.86	91.12	
Fertilization rate (kg/ha)	zero	zero		289	462	
Fertilization rate (kg NPK/ha)	zero	zero		116	185	
Fertilizer price (CIF US$/ton)	na	na		180	270	
Fertilizer value (US$m)	zero	zero		2.13	24.6	
Coffee fertilizer ratio (kg/kg)	na	na		2.07	1.51	
Optimum coffee fertilizer ratio (kg/kg)	na	na		2.68	4.55	
Coffee/Fertilizer price index	na	na		16.9	11.26	
Coffee revenues (million US$) (sales/fertilizer value)	402.93	342.01		72.66	394.2	
Additional forex generated from applied fertilizer (US$ m)	zero	zero		13.82	95.06	
Ratio of additional forex generated to fertilizer value	na	na		6.49	3.86	
Additional forex per unit of fertilizer (US$/t fertilizer)	zero	zero		1165	1043	

2.3.3 Foreign Exchange Generation Through Exports of Potash

Technical aspects of the exploitation of potash ore and manufacture of a range of potash fertilizers are discussed later in section 2.6.

Exports of potash fertilizers would be justified only if the manufacturing cost of Ethiopia's potash were lower in the main international markets, after shipping, than the expected world price of potash at those markets. In this regard it should be noted that the price of muriate of potash, has been depressed since the mid-1980s, ranging from US$ 60 to US $ 80 per mt, at an average of US $ 70.

With high capital costs, equal to US$ 70 per mt of MOP at the start of operation of a potash fertilizer complex in Dallol (with a capacity of 1,500 tpy of MOP and a capital investment of US$ 700 million), competing in international markets would be very difficult. However, a real opportunity exists if some basic conditions are met. These are as follows:

- Reduction of the initial capital investment cost of the complex through increased domestic inputs in the realization of this project (TA project 16);
- Diversification of the production programme to include the whole range of potash products, some of which (even SOP) are more valuable than MOP (TA project 14);
- Reduction of the manufacturing costs of potash products through the use of cheap sources of energy (solar, geothermal and hydroelectric) (TA project 15).

If MOP were the only product for export, this investment would appear to be insufficiently remunerative, as even a net profit of US$ 30 per mt of MOP would bring foreign exchange revenues of only US$ 45 million per year (1.5 million tpy x US $ 30/1 mt MOP).

Conclusion

Increased supplies of fertilizer, from foreign and possibly domestic sources, may be a superior option to reliance on imports of grains. Establishing a domestic fertilizer industry may thus be a superior option to reliance on imported fertilizers. Once this possibility is accepted, as it has been in Ethiopia, specific investment proposals and strategy choices must be assessed in nitrogen, phosphate and potash fertilizer production.

The following sections consider strategy choices involved once establishment of a domestic FERTIS is an accepted objective.

2.4 Analysis of Specific Development Strategies

The following sections assess the relative advantages and disadvantages of existing FERTIS investment proposals, largely from the NCC, as well as specific proposals contained in this Integrated Development Programme.

2.4.1 A Nitrogen fertilizer industry based on natural gas

Natural gas is the most widely used raw material for production of ammonia. Combined with steam and air, natural gas yields liquid ammonia and gaseous carbon dioxide. These are raw materials for production of urea, which is the most widely used straight nitrogen fertilizer in the world. Urea's high concentration (46% of N) is of importance for Ethiopia due to the extent of transportation constraints. Therefore, with the exception of DAP, urea plays the main role in Ethiopia's FERTIS development plans.

It has already been noted that varying N:P:K ratio estimates hinder the design of a single long-term FERTIS development strategy. Examination of N:P:K estimates to form a basis for planning is urgently required. The analysis presented in this Integrated Programme must thus be based on possible upper and lower estimates, as illustrated in Table 11. Using high and low estimates is of particular importance for the nitrogen fertilizer industry, as it is nitrogen which is expected to vary most in the N:P:K ratio.

Two alternative development options for the nitrogen fertilizer industry using border estimates of the N:P:K ratio are analysed here. All other options fall between these border estimates. These two options are as follows:

Option 1 - (plant located in Gode) suggested by the National Chemicals Corporation; and,

Option 2 - (plant located in cropping areas) suggested in this Integrated Programme.

Table 11: Border Limits of the FERTIS for Different N:P:K Ratios

	NCC OPTION	UNIDO OPTION
Target year	2005	2005
Fertilizer demand (tpy)	1,104,000	1,230,000
NPK Demand (tpy)	656,000	650,000
N:P:K ratio	1.00:1.35:00	1.00:0.50:0.06
Nitrogen- (N tpy)	279,000	418,000
Phosphate - (P2O5 tpy)	377,000	209,000
Import of Dap (tpy)	820,000	454,000
Nitrogen in Dap (tpy)	148,000	82,000
Nitrogen in Urea (tpy)	131,000	336,000
Demand for Urea (tpy)	285,000	720,000
Demand for Ammonia (tpy)	171,000	438,000
Ammonia Capacity (TPD)	570	1460
Urea Capacity (TPD)	950	2430
A/U Complex(es)	A 500 TPD, U 800 TPD	3x(A 500 TPD, U 800 TPD)

Within upper and lower demand limits, and given the N:P:K ratios assumed in both options, meeting nitrogen demand would require ammonia plant capacity of approximately 500 TPD (NCC) to 1500 TPD (UNIDO). Simplifying, the NCC option would require 1 plant and the UNIDO option 3 plants. Nitrogen demand based on FAO estimates would require ammonia plant capacity of around 1000 TPD, or two plants.

Considering that the NCC, MOI and the Government require a clarification of this situation in order to proceed with FERTIS development, UNIDO has re-examined the nitrogen balance from the NCC's Market Study taking into consideration the following points:

- advancing the time-base for demand projections from 2005 to 2010;
- supplementing NPK demand from cereals by demand from cash crops (an additional 20%);
- partial substitution of imported DAP for imports of TSP (30% TSP);
- total substitution of imported DAP for imports of TSP;

With an N:P ratio of 1:1.35, as in the NCC option, there is no justification for two A/U complexes in Ethiopia by the year 2010, even when additional demand for fertilizers for cash crops is included.

There is a justification for a second A/U complex (of the capacity 500 TPD A, 800 TPD U) only if imported DAP is partially substituted (30%) by imports of TSP, as only then does the nitrogen balance justify further capacity.

Finally, only if imported DAP is totally substituted by imports of TSP would there be room in the NCC's nitrogen balance for a third A/U complex. Complete substitution is unlikely because DAP is the most concentrated fertilizer, and is thus suitable for transport, carries two nutrients, and is well known among Ethiopian farmers. Substitution of DAP by TSP of more than 30% seems unlikely.

Nitrogen Fertilizer Manufacturing Costs

Analysis of the NCC and UNIDO options requires that manufacturing costs of urea should be compared in both cases. These costs are compared in table 12 taking into account the following factors:

- The investment cost of a natural gas pipeline. This pipeline would be 100 km in length for an A/U complex at Gode and 1000 km for three complexes in the cropping areas (an average 333 km for each). A cost of US $ 30 million per 100 km of pipeline is assumed. Pipeline investment costs are thus US $ 30 million and US $ 100 million for the NCC and UNIDO options respectively;
- A preferential price of US $ 3.2/Gcal for natural gas, including the cost of extraction, dehydration, compression and delivery.

Table 12 likewise details the competitiveness of domestic urea supplies to cropping areas compared with imports of urea. The NCC option (an A/U complex at Gode) would be more competitive than the UNIDO option on an ex-factory basis, but uncompetitive with imports when the cost of transporting urea to cropping areas is included. Only after several years of repaying capital would the A/U complex at Gode be able to produce and supply urea to the highland areas at a competitive cost.

For analytical purposes two further variations of the UNIDO option were examined as follows:

(a) two A/U complexes in the cropping area using pipelined natural gas, with a pipeline distance of 500 km (this option is close to FAO's assumptions on NPK demand and the NPK ratio);

(b) one A/U complex in the cropping area using pipelined natural gas. The distance to the complex, located centrally in Ethiopia, would be 1000 km;

As shown in table 13, in terms of urea delivery to the highlands, UNIDO variation (a) is more competitive than the original NCC option, and is still competitive with imports. UNIDO variation (b) is less competitive than the NCC option and is uncompetitive vis-a-vis imports.

From this analysis it can be concluded that the NCC's option is the most efficient in terms of ex-factory urea manufacturing cost. However, when the cost of urea delivery to the highlands is taken into account, the NCC option is less effecient than the UNIDO option (and its variations).

For one A/U complex, the point at which urea delivery costs to cropping areas is the same in both the NCC and UNIDO options lies at a distance of some 700 km from the natural gas source at Calub. A natural gas pipeline longer than this will diminish the relative effectiveness of the UNIDO option.

Hence, in terms of delivery of fertilizer to cropping areas (Arsi, Keffa), the A/U complex recommended in this Integrated Programme, located in the Yirga Alem region, would have a cost effectiveness similar to that for the A/U complex at Gode. However, these two locations are almost mutually exclusive alternatives, as construction of an A/U complex at Yirga Alem would leave open the possibility of extending the natural gas pipeline further to the north (Mojo) if future FERTIS development is to address the growing nitrogen demand. Investing in such a long pipeline to Mojo, to feed a single new plant, would be extremely uneconomical. This is what would be required if the investment at Gode were to proceed and later FERTIS development were to address the rising nitrogen demand.

Discussion

The goal of minimizing the investment cost for the natural gas pipeline has led the NCC to select Gode as a project location. However,

Table 12: <u>The Domestic Manufacturing cost of Urea and its Competitiveness with the World Market</u>

	NCC OPTION	UNIDO OPTION
<u>Ammonia Plant 500 tpd including NG pipeline</u>		
Natural gas at 7.2 Gcal/t	23.0	23.0
Other variable costs	9.0	9.0
Capital related costs at 15%	175.0	220.0
Other fixed costs	15.0	15.0
Production cost in US$/t	222.0	267.0
<u>Urea Plant 800 tpd Including Urea Bagging</u>		
Ammonia for urea at 0.6 t/t	133.0	160.0
Other variable costs	22.0	22.0
Capital related costs at 15%	60.0	50.0
Other fixed costs	10.0	10.0
Production cost in US$/t	225.0	242.0
Capital related costs to improve road network to the highlands	25.0 US$/t	0.0 US$/t
Cost of Urea transport to FERTIS stores in the highlands	75.0 US$/t	10.0 US$/t
Landed cost of Urea Loco Central Fertilizer stores	325.0 US$/t	252.0 US$/t
Landed cost of bagged Urea CIF Assab port	180.0 US$/t	180.0 US$/t
Cost of Urea Transport from Assab to cropping areas	120.0 US$/t	120.0 US$/t
Landed cost of imported bagged urea to Ethiopia's central stores	300.0 US$/t	300.0 US$/t
Competitiveness of domestic Urea production with imports	(-25 US$/t)	(+48 USU$/t)
Net difference in Urea delivery costs	0.0 US$/t	+ 73.0 US$/t

Table 13 Landed Cost of Urea Delivered to the Highlands

	NCC	UNIDO	UNIDO	
A/U complexes	1	3	2	1
NG pipeline km	100	333	500	1050
Ammonia Manufacturing (cost US$/t)	220	265	315	435
Urea Manufacturing (cost US$/t)	224	241	271	343
Landed cost of urea at the highlands	324	251	281	353

notwithstanding weak infrastructure at Gode, there is only a small demand for urea in this region. This drawback might be addressed through an exportagreement with Somalia or by transporting the regional surplus of urea to highland cropping areas. The latter would require upgrading of some 600 km of road connecting Gode with Shashemane (Figure 1).

Improving the interregional road might be a preferred line of action if there were no prospects for further nitrogen complexes in Ethiopia, and if the cost of transporting urea by road were lower than that of pipelining natural gas to the same location. However, there are prospects for additional nitrogen fertilizer complexes, while the cost of transporting urea from the Calub-Gode area to highland areas would be around US $ 75-100 per mt of urea, approximately double the cost of pipelining natural gas. Under these conditions competitiveness with imported urea would be lost. This situation is represented diagrammatically in figure 9.

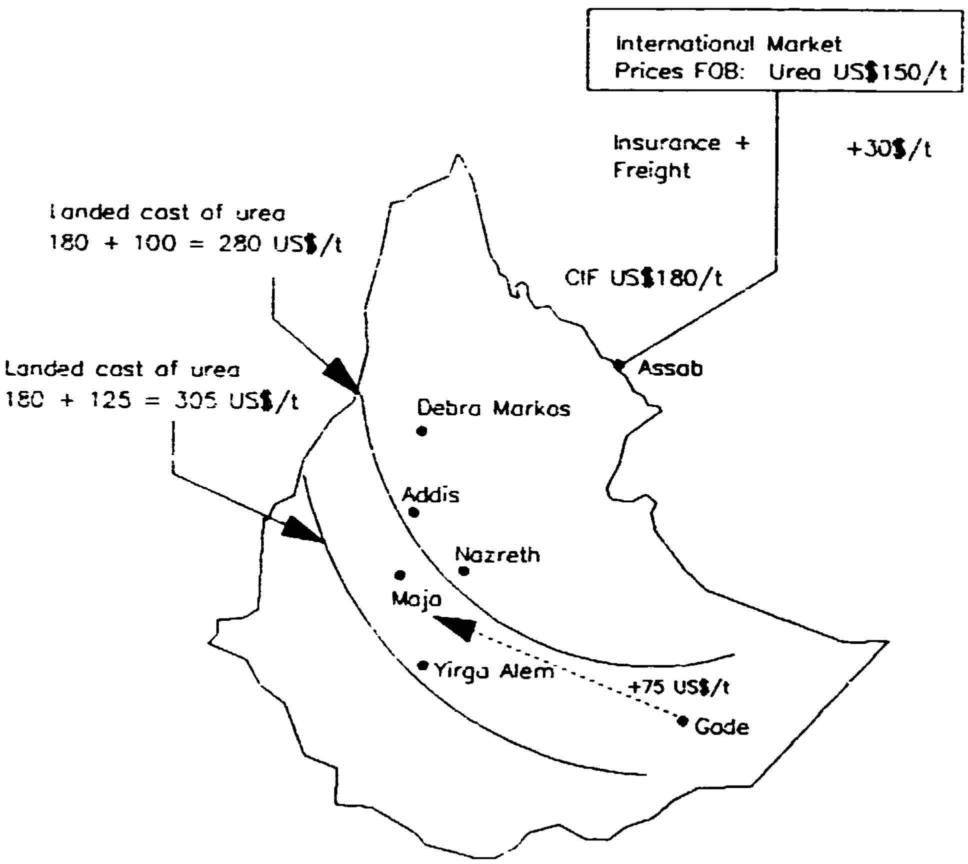
If the A/U complex at Gode is built, at least one nitrogen fertilizer complex may be required soon after to cover the shortfall in nitrogen demand by the year 2005. A second nitrogen complex located in the highlands, some 700-1000 km from the gas deposit, would not pay for the construction of such a long pipeline. At that time, due to new infrastructure, Gode may by default become a national fertilizer center with an ammonia capacity of at least 1000 TPD, but with high transportation costs incurred in moving fertilizer to distant highland areas.

Such an option might be considered and even given priority if the second fertilizer complex, producing nitrogen-phosphate, made up the nitrogen and phosphate shortfall by the year 2005, meeting the huge demand for DAP and utilizing natural gas and phosphate deposits located in Ogaden. The NCC option, in which the N:P ratio favours phosphate, might be open to this scenario (were it not for uncertainty over the processing characteristics of Ogaden phosphate rock). However, as the future N:P ratio may shift more towards nitrogen than is envisaged in the NCC programme, three A/U complexes (each with a capacity of 500 TPD A and 800 TPD U) may be needed by the year 2005. In such a case, Gode would be a non-optimal location for distributing urea in the highlands.

By contrast, a recommendation is here made in favour of pipelining natural gas to the cropping areas and construction of two (500 TPD A, 800 TPD U) complexes there. The third, nitrogen-phosphate, complex would then ideally be located at Gode, depending on the degree of development of the phosphate raw material base.

Figure 9

FERTIS IMPORT SUBSTITUTION SCENARIOS FOR THE NITROGEN FERTILIZER INDUSTRY IN ETHIOPIA



"FERTIS" import substitution scenarios should be based on comparison of the cost of imported urea at Ethiopia's Highlands versus the cost of urea manufactured domestically and delivered to cropping areas in the highlands (Arsi, Shewa, Gojam). Very high transport costs of urea from Assab to Addis Ababa, Maja, Nazreth and Yirga Alem located in cropping areas give additional possibilities for establishment of a domestic nitrogen fertilizer industry competitive with imports.
Gode is also located favourably for competition with world market prices on an ex-factory basis. However, urea from Gode will have to be delivered to cropping areas in the Highlands to meet urea demand there. This should be taken into consideration while comparing different import substitution strategies for the fertilizer nitrogen industry (pipelining of natural gas versus road transport of urea).

Source: The British Sulphur Corporation Ltd.,
"Nitrogen No. 156 through 194, 1985-1991;
"Phosphorus & Potassium" No. 145 through 176, 1986-1991
"Sulphur" No. 197 through 203, 1988 - 1989 and data from AISCO.

It is recommended that the first ammonia-urea complex be built in the Yirga Alem area (phase I), rather than Gode. It is recommended that Phase I be supplemented by construction of an ammonia-urea complex in the Mojo area (phase II). These recommendations are depicted in figures 10, 11 and 12.

Construction of a nitrogen-phosphate complex, phase III, would depend on the degree of development of the phosphate raw material base by the year 2000-2002. If sufficiently developed, priority would be given to a nitrogen-phosphate complex at Ogaden (Gode) or Wollega (Bikilal phosphate deposits). If the phosphate raw material base is not sufficiently developed, then a third A/U complex located in either Mojo or the Debra Markos area is recommended (Figure 10). The relative merits of ammonia/urea complexes at these and other locations will be examined in projects which form a part of this Integrated Development Programme (projects 8 and 9).

Since the cost of transporting fertilizer to the cropping areas will be key in establishing the import competitiveness of a domestic fertilizer industry, a south-west natural gas pipeline route (Calub-Gode-Negelli-Yirga Alem-Mojo-Addis Ababa) is considered more advantageous than a north-east pipeline route (Calub-Dire Dawa-Metahara-Addis Ababa) (see map of alternative pipeline routes in TA project 8).

<u>Comments on Assumptions Made in the Appraisal of the Gode Project</u>

Some assumptions adopted by the NCC and the IFDC relating to the location, capacity and viability of the A/U complex at Gode, might be re-examined. These assumptions include the following:

- A/U capacity: Nitrogen demand in the years 2000-2010 suggests much bigger A/U capacities than those selected for Gode. This location is not compatible with a larger programme.

- Prices of natural gas to feed the ammonia plant: These prices are considered too high, especially the price of 13.6 US$/Gcal. The low price estimate of 4.0 US$/Gcal seems too high. An alternative base case price might be 4.0 US$/Gcal, with a low case price of 3.2 US$/Gcal.

- An investment location factor (ILF) of 1.17, selected by the IFDC, may be too low given the lack of basic infrastructure at Gode. The time-schedule for the construction of the A/U complex in this semi-remote location should be re-assessed.

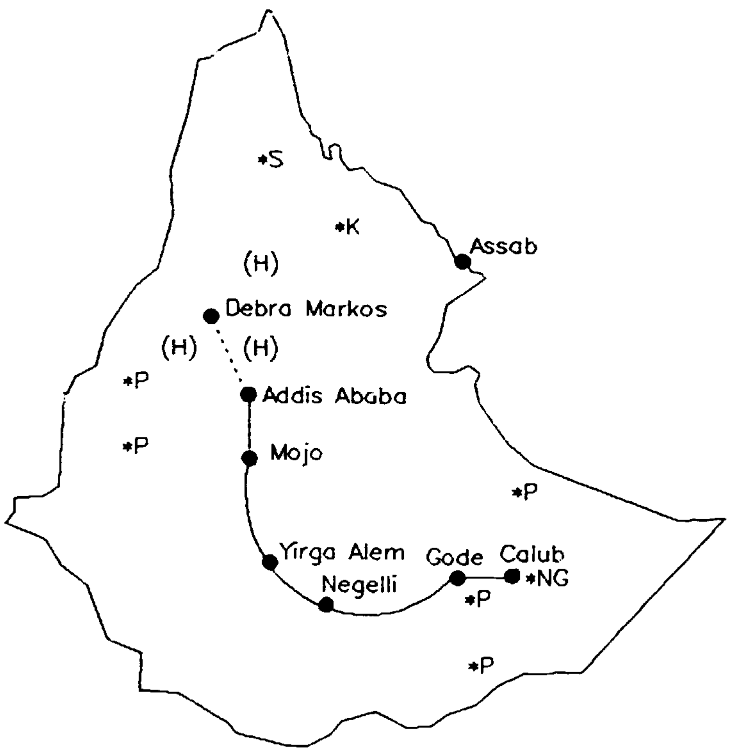
- The investment cost for the A/U complex at Gode has not included a 100 km natural gas pipeline from Calub to Gode, or some other associated costs, such as general infrastructure, an HV grid connection and a urea handling and transportation network. This issue should be clarified in order to decide on the additional investment needed for the off-site and non-process facilities.

- Assumptions made in preparing the sensitivity analysis of the project might be re-examined, especially with regard to:

1. a urea selling price of 600 birr per ton (equivalent to US$ 290/ton), especially considering additional costs for transport of urea to cropping areas that would be borne by the farmers.
2. the influence of possible delays in construction on the project's NPV and IRR.

Figure 10

Natural Gas Development Scheme in Ethiopia



Indicative locations of FERTIS related raw materials:

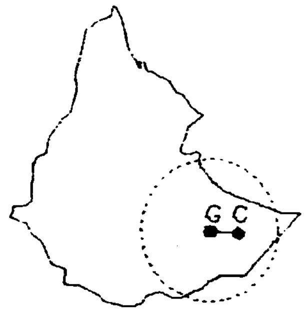
NG–Natural Gas (Nitrogen); P–Phospate Rock and/or Apatite; S–Pyrites (Sulphur) and K–Potash.

The major hydroelectricity potential (H) at the Blue Nile River basin has been indicated to illustrate a possible route to ammonia by water electrolysis.

Source: Data and information derived from different Ethiopian Organizations: MOI, NCC, AISCO, MOA, EIGS, ELMICO EELPA, MCTD, NFIU, AIDB, EAL, IAR, as well as FAO, UN, ADB, World Bank, ECA, UNDP in Addis Ababa – field missions to Ethiopia, December 12 – 27, 1989 and November 18 – December 6,1991.

Figure 11 Alternative locations for a large A/U complex in Ethiopia

A. Ammonia Plant 1500 TPD located at Gode

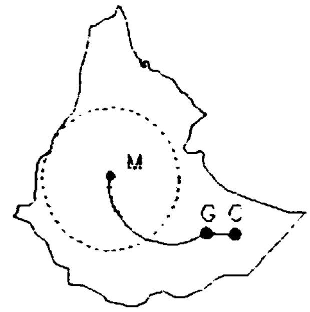


A/U complex at Gode

N Gas pipeline 100 km from the gas well head at Calub

Option with minimum investment but with higher landed cost of urea to the farm gate in the Highlands

B. Ammonia Plant 1500 TPD located in the cropping area (Mojo region)



A/U complex at Mojo

N Gas pipeline 1000 km, 100 + 900 from the gas well head at Calub

Option with higher investment but lower landed cost of urea at the farm gate in the Highlands

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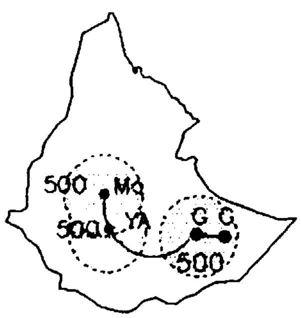
Figure 12 Alternative locations of three A/U complexes in Ethiopia

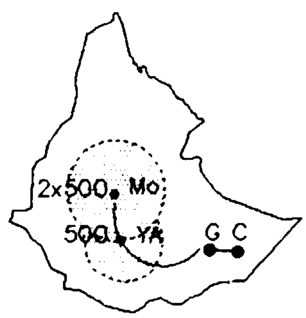
C. Three Ammonia Plants 500 TPD each at Gode Yirga Alem and Mojo



N Gas pipeline
100 + 900 = 1000 km

Distribution of urea in cropping areas is worse than in option D.

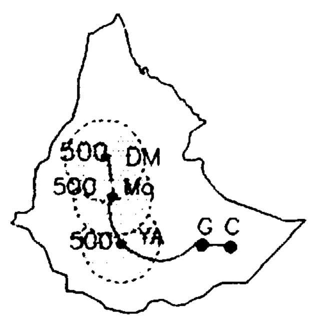
D. Three Ammonia Plants 500 TPD each at Yirga Alem and Mojo



N Gas pipeline
100 + 900 = 1000 km

Distribution of urea in cropping areas is better than in option C.

E. Three Ammonia Plants 500 TPD each at Yirga Alem Mojo and Debre Markos



N Gas pipeline
100 + 900 + 300 = 1300 km

Distribution of urea in cropping areas is better than in option C and D.

3. the impact of larger sensitivity changes on the project, as the range of 5-10% may be too narrow.
4. the impact of positive changes in the project could be analyzed (construction of the complex ahead of time, foreign exchange savings, achievement of higher than nominal yearly capacity of the complex, etc.). This might allow the Government to mobilize resources aimed at achieving optimum results from the A/U complex.

In summary, the financial and economic viability of the A/U complex at Gode, and its competitiveness with urea delivered from international markets to cropping areas, may change after the above remarks are considered.

Figure 13 compares the expected outcome of the NCC and UNIDO FERTIS investment proposals by the year 2005. Ethiopia's population will have reached 71 million inhabitants by that time. A cultivated land area is assumed of 8.5 million ha (the NCC assumed 7.0 million ha). According to maximum estimates, fertilizer nutrients demand will be around 650,000 tpy of NPK. An NPK production shortfall in the year 2005 would occur for the nitrogen related programmes of both the NCC and UNIDO.

The phosphate raw material base is not sufficiently developed to have begun domestic production by the year 2005, while potash is of minor importance for domestic use. Consequently, the NPK shortfall mainly affects phosphates, as shown in Table 14:

Table 14: The NPK Production Shortfall in 2005 - Options of the NCC and UNIDO

	NCC	UNIDO
Fertilizer Product (tpy)	1,104,000	1,230,000
N:P:K ratio	1:1.35:0	1:0.5:0.06
NPK Demand (tpy)	656,000	650,000
- Nitrogen Demand (tpy)	279,000	418,000
- Phosphate Demand (tpy)	377,000	209,000
- Potash Demand (tpy)	---	23,000
Nitrogen Production (tpy)	105,000	331,000
Phosphate Production (tpy)	---	---
Potash Production (tpy)	---	23,000
NPK Production (tpy)	105,000	354,000
NPK shortfall (tpy)	551,000	296,000
- nitrogen shortfall (tpy)	174,000	87,000
- phosphate shortfall(tpy)	377,000	209,000
- potash shortfall (tpy)	---	---

Simplifying, we assume that the shortfall in phosphate is equivalent to that in DAP. This implies a need to supply from the international markets some 820,000 tpy of DAP in the option of the NCC, versus 450,000 tpy of DAP in the option of UNIDO. The import shares in the total amount of consumed fertilizer product would be 74% and 34% for the NCC and UNIDO options respectively. Bearing in mind that the full scope of investments to be realized is not yet clear, Table 15 presents further basic indicators of the UNIDO programme and the Government programme by the year 2005.

Table 15 Basic Indicators of the Government and UNIDO Programme by 2005

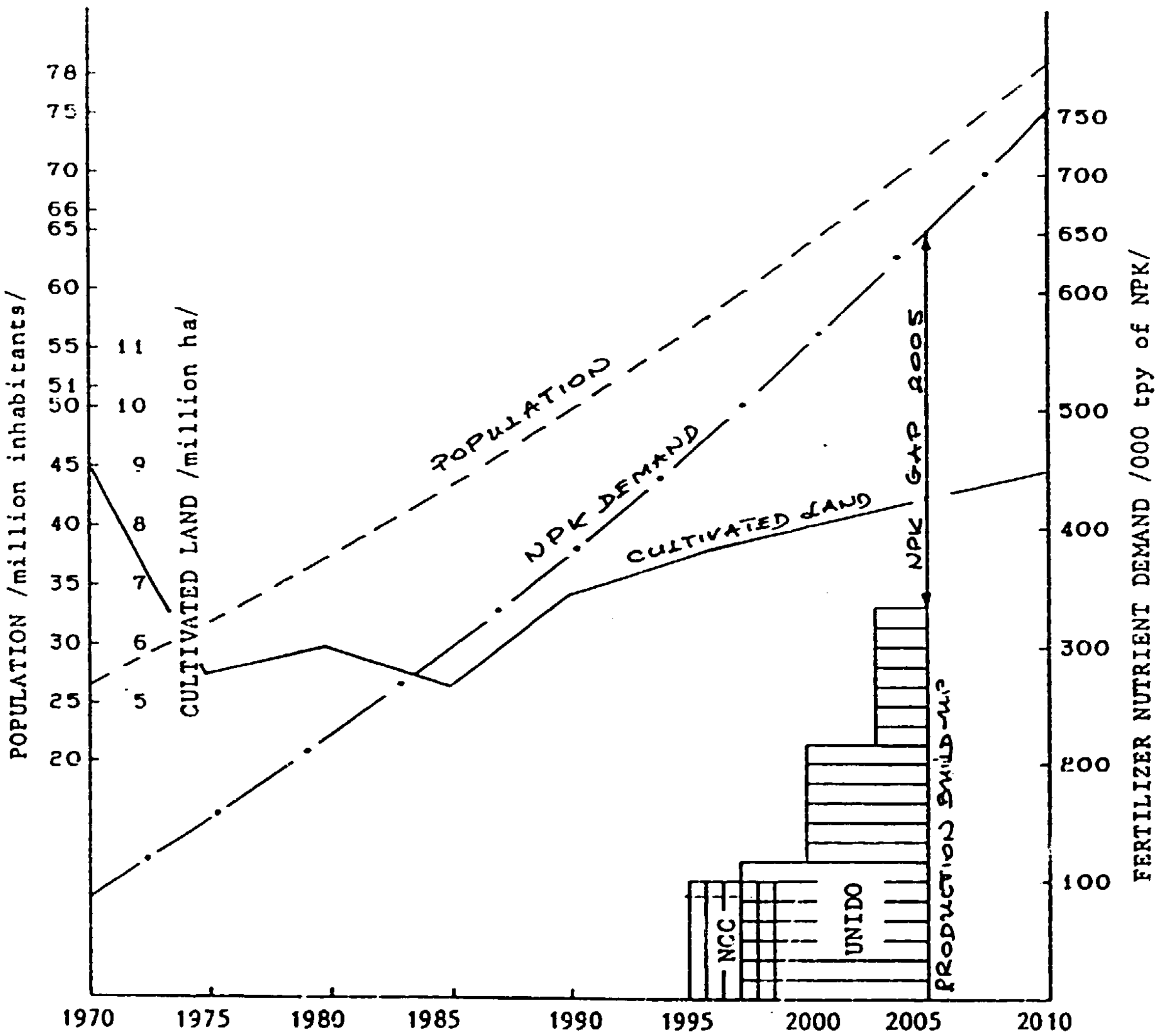
INDICATOR	WITHOUT FERTIS	WITH FERTIS	
		GOVERNMENT	UNIDO
NPK demand (000 tpy)	650	656	650
NPK production (000 tpy)	---	145 N	354 NK
Equivalent grain production (000 tpy)	---	1,117	2,726
Import substitution in NPK (%)	---	22	54
Imports/grants (000 tpy product)	1,250	880	470
Unloading rate in Assab (TPD)	4,170	2,930	1,570
Value of imports/grants (mln US$)	390	307	178
Overall transport cost (mln US$)	125	108	58
Overall supply cost (mln US$)	515	492	413
Net yearly savings (mln US$)	---	23	102
Cost of supply per 1 t NPK (US$)	792	750	635
NG Pipeline (km)	---	100	1,000
NG requirements (mln cum per year)	---	135	450
Power requirements (MW)	---	60	---
Ammonia capacity (TPD)	---	600	1,500
Urea capacity (TPD)	---	765	2,400
CAN capacity (TPD)	---	500	---
MOP/SOP capacity (TPD)	---	---	150
Total investment (mln US$)	---	351	930
Specific investment (US$/t NPK/year)	---	2,420	2,630
Number of investment phases	---	2	4
Time-frame for the programme	2005	1994-2002	1996-2005
Investment in Phase I (mln US$)	---	256	410
Specific Inv.(Phase I, US$/t NPK/year)	---	2,440	3,720
Time-frame for Phase I	---	1994-1998	1996-2000

Assumptions made in the preparation of table 15 include the following:

- A price of US $ 15 / MWh has been used for the calculation of the CAN production cost.
- The cost of supply relates to the delivery of 1 t of NPK to main agricultural areas.
- A cost of US $ 30 million per 100 kms of natural gas pipeline is used.
- Total investment cost does not include either expansion of the port of Assab, the Assab corridor and stores, improvement of the Gode-Shashemane road or investment in hydropower plant.
- The number of investment phases relates only to indicated plants, and does not include preparatory phases or other activities

Figure 13

FERTIS DEVELOPMENT STRATEGIES IN ETHIOPIA BY THE YEAR 2000 AND BEYOND



Sources: EIU, The Economist Intelligence Unit - Country Profile: Ethiopia, 1989-90 and 1991-92, and Country Report No.3

World Development Report 1988 - The World Bank, 1988
Sub-Saharan Africa - From Crisis to Sustainable Growth, The World Bank, 1989
Market Study for Fertilizer in Ethiopia, National Chemical Corporation, Ministry of Industry, Jan. 1991
Data from MOI, NCC, AISCO, MOA, EIGS, ELMICO, EELPA etc.

Summary

Knowing the major advantages and disadvantages of both options the Government of Ethiopia will be in a position to decide which should be given priority: that recommended by the NCC, or that recommended here and based totally on natural gas.

If the Government were to find the NCC option for an A/U complex at Gode preferable, it would be ideal if this option were incorporated into this Integrated Programme as a phase I. The drawback to the NCC option in terms of the limitations this may impose on future FERTIS development have already been noted. One possibility to make the NCC and UNIDO options more compatible might be the role of other natural gas consuming industries (iron, metallurgy, glass, petrochemicals) in justifying a natural gas pipeline from Calub to the highlands. This possibility will be explored in this Integrated Programme.

Preparations for a fertilizer complex at Gode are still of great value, even if the NCC option were not accepted, as they may be used subsequently to accelerate realization of a nitrogen-phosphate complex in Ogaden.

Given the importance of the NCC option, it is recommended that both options be pursued in parallel until a final decision on the scope of the programme can be made. Such a situation may arise immediately after TA project 6, a seminar on fertilizer demand and an optimum N:P:K ratio, has been implemented. Project 6 is thus first in the overall schedule of this Integrated Programme.

2.4.2 Considering Ammonia Production by Water Electrolysis

Although some elements of the NCC option may be sub-optimal, time and initial investment costs clearly favour this option. An option of ammonia production by electrolysis of water is thus presented here that might be considered complementary to NCC's strategy. Complementarity would result in part through increasing nitrogen production (even though urea cannot be produced by this route), and because the location of fertilizer facilities in the Blue Nile River Basin would obviate the need to invest in a long natural gas pipeline. While any investment decision must be preceded by detailed quantitative analysis, the principal factors to be considered in a general assessment of electrolysis based production are outlined in the remainder of this section.

Ethiopia has a huge hydroelectric power potential, estimated at at least 60,000 GWh per year. Only about 10 per cent of this potential is to be utilized by the year 2010 (see Annex 1 on geothermal energy potential).

Hydroelectric plants are the basis of a major energy development programme covering the period 1982-2005. Costing an estimated 3,700 million birr (equivalent to about US $ 1,800 million), the programme is designed to raise total installed generating capacity from 300 MW to 1,000 MW by linking three existing grids into one domestic network with connections for exports of electricity to Djibouti and Sudan.

The largest hydroelectric power potential, over 60% of Ethiopia's total potential, is located in the Blue Nile River basin, as illustrated in Table 16:

Table 16 Hydroelectric Power Potential in Ethiopia

Hydro-electric power potential	MW	% of total
- Blue Nile River Basin	9100	61.3
- Baro Akobo	2240	15.1
- Wabe Shebele	1610	10.8
- Gibe Omo	1310	8.8
- Awash	300	2.0
- Northern Rivers	150	1.0
- Genale Dawa	150	1.0
Total potential	14,860	100.0%

The industrial route to ammonia based on electrolysis of water requires large amounts of energy and is usually associated with a hydroelectric power source. Because of its hydroelectric power potential, the Blue Nile River (Abay) Basin should be examined first as a possible location for future ammonia plants.

Hydrogen, derived from electrolysis of water, and nitrogen, produced by air liquefaction and separation, are intermediates leading to liquid ammonia that can be processed subsequently to nitric acid (NA), ammonium nitrate (AN), and calcium ammonium nitrate (CAN).

However, a natural gas based route to ammonia, even requiring investment in a pipeline, would be more effective for large capacities than the route to ammonia by water electrolysis. Nevertheless, given the high cost of transporting fertilizer by road from Gode to the cropping areas, small-scale ammonia plants based on the electrolytic route might be as efficient as the NCC option, especially in remote locations in the highlands and or in the vicinity of hydro-electric power stations.

To analyze the technical and economic viability of the electrolytic route to ammonia, power requirements must be compared with installed and planned power generating capacity, as illustrated in tables 17 and 18:

Table 17

Installed and Planned Power Generating Capacity in Ethiopia

HYDROPOWER PLANT	START-UP YEAR	INSTALLED/PLANNED CAPACITY
Koka Dam (Awash I)	1960	30 MW
Tissisat Dam	1964/1995	30 MW
Awash II	1964	32 MW
Awash III	1971	32 MW
Finchaa	1974	100 MW
Malka Wekana	1988	150 MW
Sor	1992	5 MW
Gilgel Gibe	1995	150 MW
Aleltu	1999	300 MW
Chemoga Yeda	2005	300 MW
All hydropower plants	1960/2005	1,129 MW

From discussions with the Ethiopian Electric Light and Power Authority (EELPA), it was learned that price/cost estimations for hydroelectricity are as follows:

- an average price of electricity for industrial use of 200 birr/1 MWh (equivalent to US $ 97 / 1 MWh);
- an average manufacturing cost of electricity of 70 birr/1 MWh (equivalent to US $ 34 /1 MWh);
- a total depreciation time for a hydrodam/hydropower station estimated at about 50 years, implying that none of the existing hydropower stations will have totally depreciated by the years 2000/2010 and only some will be partially depreciated by that time.
- a transmission cost of hydroelectricity of about 3 birr/1 MWh (around US $ 1.5 /1 MWh).

Table 18 Power Requirements for Ammonia Plants Based on Water Electrolysis

	Ammonia Capacity TPD			
	15	100	300	500
Power for electroylsis MW (direct current)	5.4	36	108	180
Power for air fractionation MW	0.1	0.5	1.4	2.3
Power for ammonia synthesis MW	0.5	3	9	15
Overall power requirements MW:	6.0	36.8	118.4	197.3

As shown in table 17, the total installed capacity of the five, partially depreciated hydropower stations (Awash I, Tissisat, Awash II, Awash III and Finchaa) is equal to 224 MW. Therefore, in commercial terms, excluding any subsidy on hydroelectricity, the maximum capacity of ammonia plant(s), based on an electrolytic route to be built by the year 2005 should not exceed 150 TPD. This ammonia capacity would require 60 MW, or about 25% of the installed power capacity from the five hydropower stations.

The economic viability of the route to ammonia by water electrolysis should be compared with that of:

- ammonia production by steam reforming of natural gas at Gode with natural gas pipelined to the cropping areas.
- exports of hydroelectricity to Djibouti and Sudan, to compare the costs of either producing ammonia by water electrolysis, or purchasing nitrogen fertilizer with foreign exchange earned from exports of hydroelectricity.

When considering the viability of ammonia production by water electrolysis, two main factors influence final costs, namely capital charges and electricity costs. It is therefore essential for this type of process that electricity is available at a reasonable price. Power consumption per ton of ammonia is 10 MWh. Thus for each US$ 10 increase in the cost of a MWh, the ammonia production cost will increase by US$ 100. It is therefore essential to use the least expensive source of hydroelectricity to obtain commercial viability of ammonia production with this route. Typical production costs for a 300 TPD electrolysis-based ammonia plant are given in Table 19:

If the cost of hydroelectricity is equivalent to US $ 10 /1 MWh, ammonia production will cost US $ 243 /ton (similar to that at Gode). For a hydroelectricity cost of US $ 20 /1 MWh, the cost of ammonia production will rise to US $ 343 /ton (similar to that if two A/U complexes are built in the cropping areas). Therefore, the maximum cost of hydroelectricity for economically viable ammonia production in Ethiopia, based on the electrolytic route, is around US $ 20 /1 MWh (40 Birr/1MWh).

Table 19 Cost of Ammonia Production by Water Electrolysis

Capital cost charges (15% of investment)	US$ 12.0 mln
Operating personnel (60 persons at 5,000 USD/year)	US$ 0.3 mln
Maintenance and materials (2% of investment per year)	US$ 1.6 mln
Steam, cooling water, utilities	US$ 0.4 mln
Total yearly production cost	US$ 14.3 mln
Total yearly ammonia production	100,000 tons
Unit ammonia production cost	143 US$/1 ton of plus electricity cost

Due to the hydroelectric power potential in the Blue Nile River Basin, and because of the fertilizer distribution pattern in the highlands, both Tissisat and Finchaa hydropower systems, situated north west of fertilizer stores in Addis Ababa, Mojo and Nazreth, may be proper locations for electrolysis-based ammonia plant(s). Depending on the overall demand for nitrogen, and the availability of cheap hydroelectricity in the Finchaa/Tissisat region, one or two electrolysis-based ammonia units, with an overall capacity of up to 150 TPD, could be considered for construction by the year 2005.

A well proven environmentally clean ammonia process exists with a capacity of as low as 15 TPD through to a typical plant size of 200 TPD and larger. Compact design and the possibility of connecting electrolysers in series/parallel, permit a reduced plot area and potential for further plant expansion. With proper maintainance, as the example of a similar plant in Zimbabwe (Que Que) shows, the plant may achieve up to 362 days of continuous operation per year.

Ammonia is an intermediate, and further processing to nitrogenous or phosphatic fertilizer is required. A typical route to nitrogen fertilizers includes the following chain of plants: A + NA + AN + CAN. A typical route to nitrogen/phosphate fertilizers includes the following chain of plants: A + NA + NP (nitrophosphates) + CAN. CAN is co-produced with NP. A reliable source of carbon dioxide is necessary in this production chain. Production costs of an A/NA/CAN complex located in Finchaa are illustrated in Annex 3.

It should also be borne in mind that the more diversified the downstream fertilizer production system (NA, AN, CAN) the greater will be the economic viability of the programme or, in another words, the higher will be the cost of hydroelectricity that can be accepted for such a fertilizer programme to be viable.

Finally, it should not be forgotten that the route to ammonia by water electrolysis offers the advantage of being based on renewable source of energy, namely hydropower.

2.5 Development Strategies for Phosphate Fertilizer Sub-system

Given a large demand for phosphate fertilizers, and an undeveloped phosphate raw material base (sulphur bearing raw materials and phosphate rock/apatite), it should be stressed that the phosphate subsector is the main bottleneck to balanced development of the FERTIS in Ethiopia. There is a need to apply priority measures to this sub-sector to avoid long-term dependency on imports/grants of fertilizers.

Phosphate is the most important component of the FERTIS. This results from the N:P ratio of around 1:1.5 used in recent years. DAP (18-46-0) is the most important carrier of phosphate and the most popular fertilizer among farmers, even ahead of urea (46-0-0) which is gradually gaining a market.

The disaggregation of NPK demand into individual nutrients illustrates best the long-term phosphate balance according the N:P ratio adopted in different options, and the time period covered. This disaggregation is illustrated in Table 20:

Table 20 Long-term Phosphate Balance - Different Options

	UNIDO	FAO	NCC *	NCC **
	2005	2000	1995	2005
N:P:K ratio	1:0.5:0.06	1:0.72:0	1:1.35:0	1:1.35:0
NPK (tpy)	630,000	495,000	529,000	656,000
P205 (tpy)	209,000	207,000	304,000	377,000
DAP (tpy)	454,000	450,000	661,000	820,000
Product (tpy)	1,230,000	900,000	890,000	1,104,000
DAP share (%)	37	50	74	74

* NFIU demand estimate; ** Food self-sufficiency estimate.

With increased awareness of fertilizer affinity to local crops and soils phosphate fertilizers other than DAP may increasingly be applied, including triple superphosphate (TSP), nitrophosphate (NP), and different grades of complex or blended NPK fertilizers. The pattern of those changes will depend on how quickly major infrastructure constraints in transporting less concentrated fertilizers are released. One may assume that the amount of DAP handled by the year 2005 will not exceed 0.8 million tpy and that its share in consumed fertilizer product will not be higher than 70%.

There are several options available for development of the phosphate fertilizer sub-system. These are as follows:

1. Imports of DAP (plus TSP,NP and NPK) through Assab port and Djibouti to central stores in Mojo, Nazreth and Addis Ababa. Phosphate imports are unavoidable for several years, until the domestic raw material base is developed. However, this dependency is not suggested as a long-term strategy.

2. Establishment of DAP/TSP/NPK plants in Assab, based on imported ammonia, phosphoric acid, phosphate rock and domestic potash from Dallol.

   With low international prices of DAP and TSP relative to intermediates (ammonia and phosporic acid), production of DAP/TSP in Assab would not be competitive in world markets unless there is a dramatic shift in prices in favour of DAP/TSP or a long-term preferential agreement is awarded to Ethiopia for imports of ammonia and phosphoric acid. Uncertainties also exist with regard to the future of the port of Assab.

3. Development of indigenous phosphate rock and apatite deposits in order to produce phosphoric acid and concentrated phosphate fertilizers using a common sulphur route (figure 14).

   Sulphuric acid, derived from local sulphur-bearing raw materials (pyrites) or from imported brimstone is used to dissolve phosphate contained in apatite or phosphate rock. The sulphur route (S - SA - PA) leads directly to production of triple superphosphate (TSP) and ammonium phosphates (DAP)/(MAP)/(NPK).

4. Development of indigenous phosphate rock and apatite deposits to produce concentrated phosphate fertilizers (nitrophosphates) by a sulphur-free route.

   Nitric acid is an attacking agent used here to dissolve the phosphate component of phosphate rock or apatite to yield nitrophosphates (A-NA-NP). No elemental sulphur (brimstone) or pirytes are used in this route as sulphuric acid is substituted by nitric acid. Calcium ammonium nitrate (CAN) is co-produced with nitrophosphates (NP). Ammonia, to yield nitric acid, is produced by steam reforming of natural gas or by water electrolysis. The whole chain of nitrogen fertilizers (A-NA-AN-CAN) may be developed independently when the route leading to nitric acid is chosen.

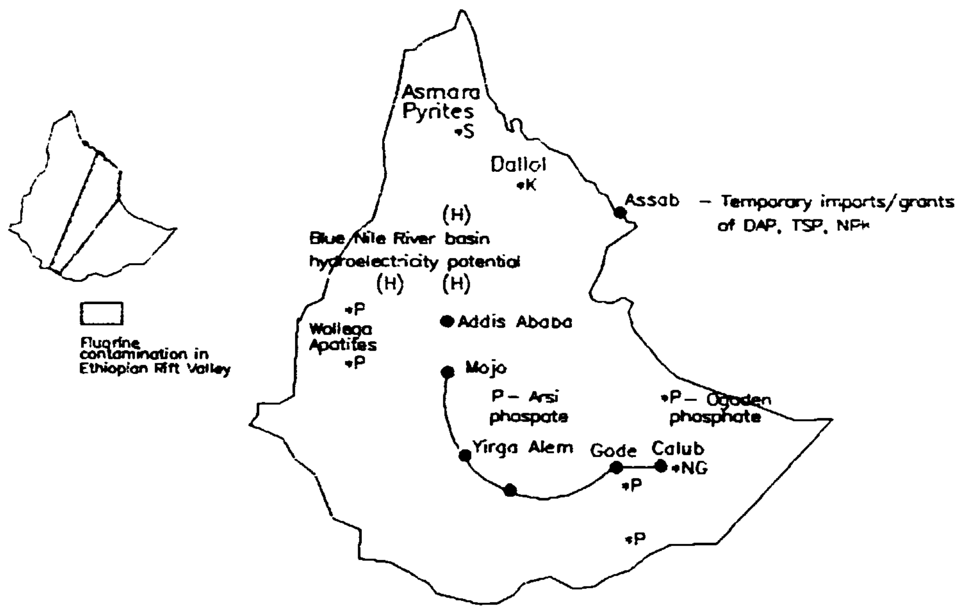
Because of the high demand for phosphate fertilizers and the time required to develop a domestic raw material base, all of the above strategies may be treated as complementary to each other.

2.5.1 Proposed Actions for Development of the Phosphate Fertilizer Industry

A proposed sequence of actions for long-term development of the phosphate fertilizer industry in Ethiopia, illustrated in figure 14, is as follows:

Figure 14

THE RECOMMENDED PHOSPHATE DEVELOPMENT STRATEGY



Recommended sequence of actions for long–term development of the phosphate fertilizer industry in Ethiopia:

A. Temporary import/grants of phosphate fertilizers. Extensive agricultural research on phosphate fertilizers.

B. Development of raw material base for the phosphate fertilizer industry.

C. Beneficiation tests of apatite in Wollega and phosphate rock in Ogaden and Arsi, ending with feasibility studies.

D. Decision on the location of phosphate mine in Ethiopia.

E. Establishment of an industrial scale phospate mine.

F. Development of local schemes for direct application of phosphate rock and PAPR process.

G. Parallel to points B through F, development of domestic sulphur bearing raw materials for sulphuric acid production.

H. Recognition and examination of the problem of fluorine contamination in the Rift Valley area in connection with planned FERTIS development.

I. Preparation of the long–term phosphate production programme

J. Establishment of linkages between phosphate and nitrogen fertilizer industries in Ethiopia.

K. Establishment of linkages between domestic nitrogen–phosphate and potash fertilizer industries.

L. Establishment of final linkages between the nitrogen–phospate–potash industries and cheap sources of hydroelectric, geothermal and solar energy.

A. Temporary imports/grants of the concentrated phosphate fertilizers (DAP, TSP, NP, NPK) supplemented with intensive research on plant nutrition, soil fertility, fertilization rates, the demand for phosphate, required N:P and P:K ratios, and optimum types and grades of fertilizers needed to formulate a production programme for the domestic phosphate industry (TA project 6).

B. Development of the raw material base for the phosphate fertilizer industry. Ethiopia requires some 10-20 million tons of pure P2O5 for a long-term development programme. Development of the raw material base would be carried out through:

B.1 Continued exploration of the Bikilal igneous phosphate deposit in Western Wollega by EIGS in order to assess the potential of the apatite deposit.

Given the low grade of apatite (ilmenite ore), with an average P2O5 concentration of 4.56%, estimated reserves of the Bikilal ore of 95 million tons, and beneficiation tests showing about 60% apatite recovery, there is little scope for this deposit to play a dominant role in long-term development of the phosphate industry. The total amount of phosphate available through this deposit can be estimated today at approximately 2.6 million tons of P2O5 (95 million tons x 0.0456 x 0.6). This volume of P2O5 would be enough to supply phosphate demand for 7 and 13 years according to phosphate requirements estimated by the NCC and UNIDO respectively.

B.2 Surveys and exploration of sedimentary phosphate rock deposits in Ogaden in terms of the extent and grade of the deposit (P2O5 content, rock reactivity and grindability, average and extreme rock analyses, R2O3, Cl, F, SiO2, CO2 content, heavy metal and cadmium impurities). The amount and character of the accessory minerals and the physical properties of the deposit also need to be considered in order to formulate preliminary conclusions on whether the deposit can be mined and beneficiated economically (TA project 11).

With a planned use of the natural gas deposit in Ogaden for ammonia production at Gode, the prospects for industrial utilization of this phosphate deposit would be high.

B.3 Surveys and exploration of other phosphate deposits already targeted by EIGS. Priority might be given to phosphate deposits in Arsi, as these may be connected in future with the nitrogen fertilizer industry (Yirga Alem, Mojo). Given very high costs of transporting bulk materials in Ethiopia, the supply of phosphate rock from abroad to locations other than Assab seems economically unjustified.

C. Pilot scale beneficiation tests of apatite and phosphate rock in Wollega, Ogaden and Arsi. These tests should aim at defining the technical viability of upgrading ore to a commercial grade phosphate (P2O5 content of a minimum 28%), the economic potential of the deposits, including the estimated cost of mining and beneficiation, the quality and grade of the beneficiated product, and environmental factors relating to mining phosphate deposits. Evaluation of the phosphate potential should end with complete feasibility studies of the above mentioned deposits (TA project 11).

D. A decision on the location of a phosphate mine(s) based on beneficiation trials and detailed feasibility studies on apatite and phosphate rock deposits.

E. Development of phosphate deposit(s) on an industrial scale through the establishment of a phosphate/apatite mine to supply phosphate to the fertilizer industry to produce concentrated fertilizers (DAP, TSP, NP, NPK).

F. Development of local schemes for direct application of phosphate rock and/or partially acidulated phosphate rock (PAPR).

At least 6 years are required for the development of Ethiopia's phosphate deposits (survey and exploration, beneficiation tests, pre-feasibility and feasibility studies, engineering work, construction of a mine with supporting infrastructure, commissioning of the mine, production start-up and build-up). Even this schedule requires that the Government give some priority to mine development (TA projects 1, 10, and 11).

G. Surveys, exploration and development of sulphur-bearing raw materials for production of sulphuric acid (native sulphur and pyrites) should be undertaken with the same level of priority as the phosphate development programme.

Although a number of occurences of native sulphur are already known (Eritrea, Tigre, Harar, and Shoa provinces), almost none has yet been the object of investigations aimed at calculating total mineable reserves. No industrial-scale exploration has been carried out following the initial discoveries. It is worth noting that sulphur deposits in Tigre and Eritrea are situated in the Dallol area, along with abundant potash reserves. Considerable reserves of copper and zinc pyrites are known to exist in the Asmara region of Eritrea (Debarwa and Adi Nefas), where at least nine huge sulphide deposits have been identified.

As native sulphur deposits are not large, pyrites are reckoned to be the most likely sulphur-bearing raw material to be developed for the FERTIS, especially as natural gas in Ogaden is sulphur-free. The massive reserves of gypsum cannot be considered an economically competitive raw material for sulphuric acid.

A detailed feasibility study on the techno-economic viability and competitiveness of domestic sulphur resources with imported brimstone is essential (TA projects 1 and 10).

H. Recognition of the problem of fluorine contamination of drinking water in Ethiopia's Rift Valley area. Conclusions regarding the effect of this problem on development of the phosphate industry in the Rift Valley area need to be formulated. This would allow the design of proper measures in FERTIS facilities to avoid acummulation of fluorine in drinking water and fluorine air pollution (TA project 10).

Fluorine contamination of waters in the Rift Valley has been a long-standing problem. Excessive concentration of fluorides in drinking water is most probably associated with the natural dissolving of minerals containing fluorides. The prolonged intake of water with excessive fluoride ions affects human beings and cattle, leading to dangerous dental and skeletal fluorosis.

I. Preparation of final phosphate demand calculations and a long-term phosphate production programme (TA project 1) taking into consideration the following points:

- agriculture's need for specific grades and types of phosphate fertilizers;
- the availability of phosphate rock/apatite and its processing characteristics;
- the availability of domestic sources of sulphur for sulphuric acid production;
- the competitiveness of imported brimstone in sulphuric acid production;
- selection of the acid for dissolving phosphate (sulphuric or nitric acid) and thus wether to employ a sulphur route and/or a sulphur-free route for production of phosphate fertilizers. This selection should take into account the demand for DAP/TSP/NPK versus NP (nitrophosphates) and the cost of producing one ton of P205 by sulphur and sulphur-free routes;
- selection of the wet phosphoric acid process from the family of modern dihydrate/hemihydrate PA processes;
- selection of fluorine combating unit operations, as well as fluorine production processes (sodium fluoride, aluminium fluoride, cryolite and others), in order to utilize by-product fluorosilicic acid from the phosphate fertilizer industry for the above mentioned valuable fluorine compounds;
- to identify appropriate diversification of the phosphate production programme, economically justified capacities of the plants, and optimum location of a phosphate (nitrogen-phosphate) fertilizer complex, taking into account, inter alia, environmental protection against fluorine contamination, transport costs of raw materials and final products, and the farm gate fertilizer price.
- the competitiveness of a domestic phosphate fertilizer industry on the world market, (or the alternative of a DAP/TSP/NPK complex in Assab based on imported ammonia, phosphoric acid and phosphate rock);

J. Establishment of linkages between the phosphate and nitrogen fertilizer industries (pipelining of natural gas or transport of liquid ammonia as against transport of phosphate rock and sulphuric acid), aiming at the minimization of manufacturing costs (DAP, TSP, NP) and the lowest farm gate price (TA projects 1, 5, 6, 7, 8, 9, 10, 11, 14, 20).

K. Establishment of linkages between the nitrogen-phosphate and potash fertilizer industries aimed at the cheapest deliveries of muriate of potash (MOP) and/or sulphate of potash (SOP) to a nitrogen-phosphate complex(es) to secure domestic production of different grades of NPK (TA projects 1, 14, 17).

L. Establishment of linkages between the nitrogen-phosphate-potash industries and hydroelectric, geothermal (and solar) energy sources to reduce fertilizer manufacturing costs (TA projects 1, 15. 16).

2.6 Development Strategies for the Potash Fertilizer Sub-system

Potassium salts must be present in soils for normal plant growth. High potash removal from soils occurs with alfaalfa, potatoes, soybeans, maize and tobacco. Potash (K20) is also used for cotton, fruits and vegetables. Potash is of great value for crops high in sugar and starch, increasing resistance to adverse soil conditions, climate and disease. Potash balances the plant food ration, counteracting the rankness of plant growth resulting from abundant nitrogen.

Thus, among the commercial fertilizers, about half as much potash is used as nitrogen (a typical N:K ratio being 1:0.5), except when the soil is capable of supplying potash. This may be the case in Ethiopia, due to decomposition of potassium minerals in the soil, as there is very little demand for potash from agriculture. TA project 6 will contribute to a clarification of this issue, especially in as far as the potash content of the soil influences the efficiency of nitrogen use.

As already mentioned, projected demand for potash by the year 2005 has not been reported in the NCC market study, the N:P:K ratio being 1:1.35:0. UNIDO has assumed a small domestic demand for potash equal to 23,000 tpy of K20, the N:P:K ratio being 1:0.5:0.06.

Exports of Potash

Given abundant reserves of good quality potash ore and limited domestic demand for potash fertilizers, a strategy of producing potash for exports may be considered (TA project 14).

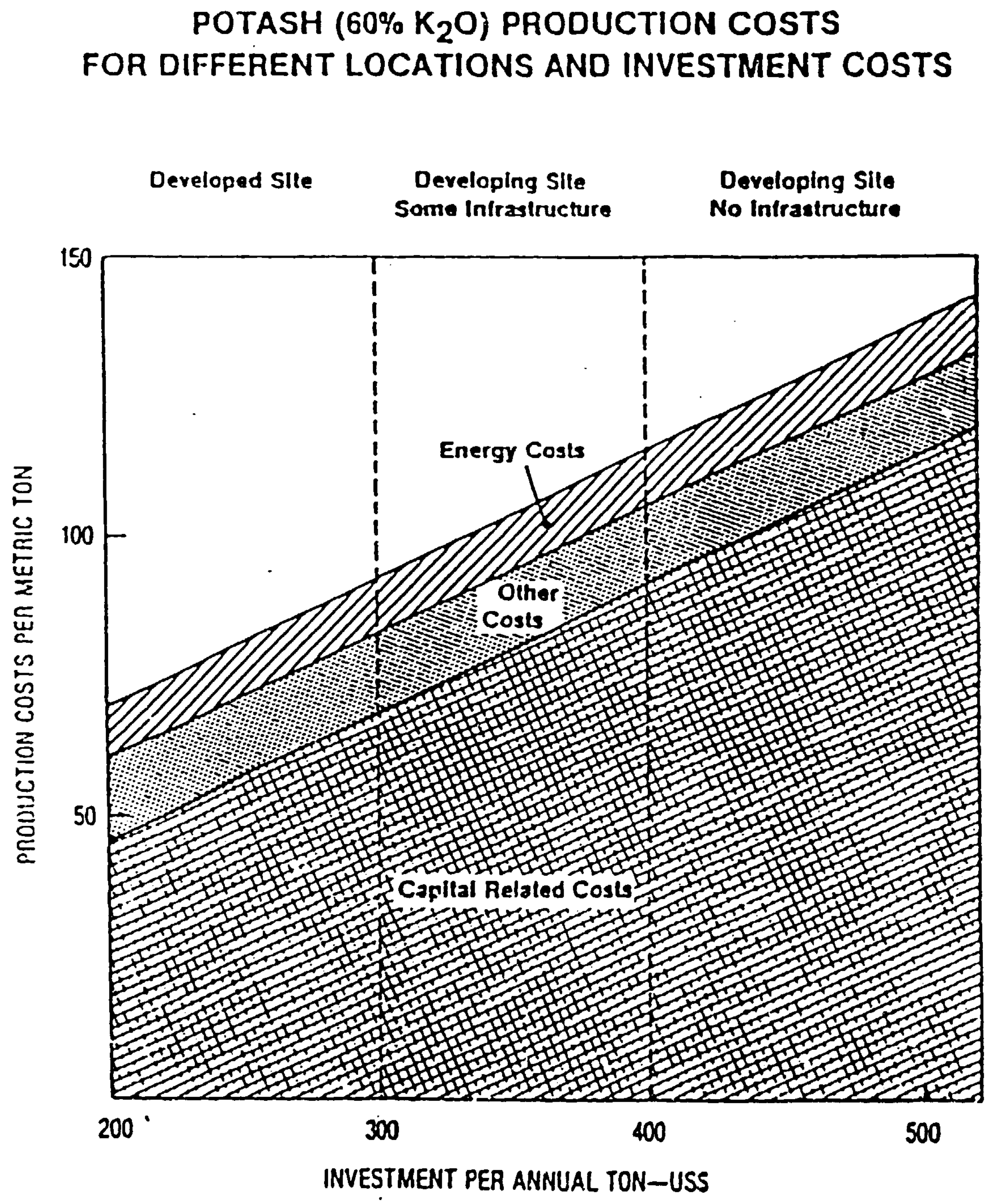
An export oriented strategy in potash should consider the movement of muriate of potash prices, and the production and investment costs of MOP in different locations having different levels of infrastructural development. Figure 15 compares production and investment costs of MOP in locations having different degrees of infrastructure. Although the costs shown in figure 15 relate to a potash shaft mine and a difficult geological formation (Saskatchewan, Canada), they illustrate a breakdown of capital related and operational costs, and show a trend in investment required for different locations.

A total investment of US $ 700 million may be needed for a potash complex with a capacity of 1.5 million tpy of MOP at Dallol, including an open-pit solution mine with refinery plant, and an export terminal at the Red Sea coast with basic infrastructure.

When investment for an export terminal and infrastructure is subtracted, a specific investment cost is arrived at for an open-pit solution mine and potash refinery of US $ 400 per ton of MOP (US $ 600 million/1.5 million tpy). Capital costs are US $ 60/ton of MOP. By adding some US $ 15/ton of MOP for operational costs, a potash manufacturing cost is arrived at of US $ 75/ton of MOP. The difference with the world price of potash is too small to pursue this project on an industrial scale in its present form.

However, evaporite deposits at the Danakil Depression contain substantial reserves of good quality potash ore such as sylvinite, carnallite, polyhalite, kieserite and kainite and can yield the whole family of potash and magnesium related products. A number of factors suggest that exploitation of these deposits may be viable. These include a strategic location for exports to Asia and South-East Africa, advantageous geological characteristics of the ore body (the potash horizon has been found at 730 m), the possibility ofdiversification in the production programme in the open-pit solution mine, and a potential reduction in the manufacturing costs of different K-Mg compounds through energy-saving programmes.

Figure 15



Source: UNIDO - ID/WG.406/3, 1983 - "The Effect of Energy and Investment Costs on Total Fertilizer Production Costs."

The recommended potash development strategy for Ethiopia is illustrated in figure 16. A preparatory phase, for implementation by the year 2000, aims at establishing pilot-scale industrial facilities (150 TPD), and would allow elaboration of a diversified production programme for a range of future exports. These exports would include different valuable potash and magnesium compounds such as muriate of potash (MOP), sulphate of potash (SOP), potassium nitrate (KNO_3), langbeinite (KMgS), and such non-fertilizer products as chemical grade potassium chloride, hydroxide and carbonate, magnesium chloride, sulphate and hydroxide, and others. Pilot-scale production would supply domestic needs for potash by the year 2000, estimated at 33,000-42,000 tpy of MOP (60% K_2O).

Activities relating to the use of hydroelectric, geothermal and solar energy in production of potash would aim to reduce operating costs (TA project 15). Reduction of capital investment and capital related costs would also be investigated (potash mine and refinery, potash terminal and infrastructure).

Before embarking on industrial-scale production, a marketing study is needed to compare the landed cost of Ethiopian potash in India, East Africa and elswhere with potash delivered from Europe, Canada and Jordan. A detailed techno-economic analysis of the project must also precede final investment decisions.

Given Africa's overall demand for potash, estimated at about 0.7 million tpy of K_2O, the project may be promoted as a sub-regional or regional activity. The project would then have to consider a production programme in line with the nutrients required by African soils.

Muriate of potash is the cheapest source of potassium. However, it contains the chloride ion, which is harmful for some crops (e.g. tobacco) and soils. Thus sulphate of potash is more frequenly used, as it also carries the valuable sulphate ion. Application of KMgS fertilizers (langbeinite) is another example of the growing importance of secondary nutrients. In this case, potash is combined with two secondary nutrients, sulphur and magnesium.

Therefore, even with serious constraints on the development of potash ores in Ethiopia, there is room for improvement of the techno-economic viability of this goal.

2.7 Quantitative Analysis of Alternative Options for Overcoming FERTIS Bottlenecks and Constraints in Order to Reach Priority Targets

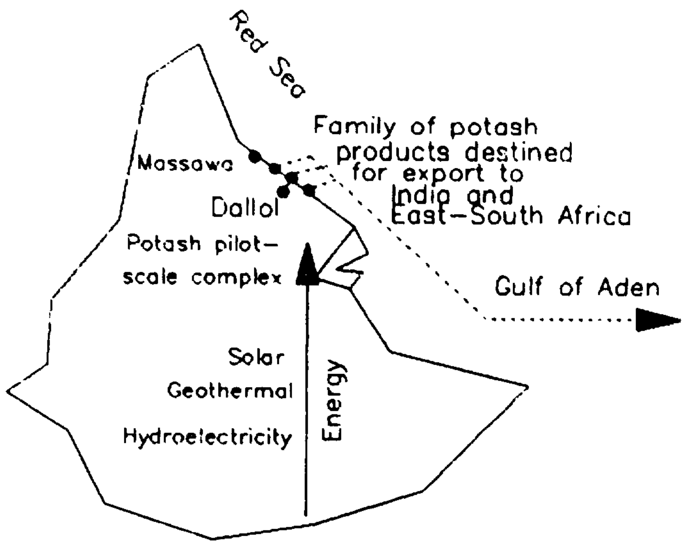
The Government "programme" here refers to the sum of Government objectives, plans and on-going activities. The Government "programme" does not include all primary nutrients, and is limited mainly to the nitrogen sub-system. It should thus be borne in mind that the Government "programme" does not refer to a single comprehensive set of actions presented as such in any policy document.

The Government and UNIDO programmes are based on a nutrient demand of around 650,000 tpy of NPK by the year 2005. They [illegible] different, however, in terms of the N:P:K ratio used. The [illegible] in the Government programme is 1:1.35:0 and is based on the NCC's [illegible] Market Study of January 1991. In the UNIDO programme this ratio is 1:0.5:0.06 and is based on long-term fertilizer recommendations gathered from the IAR in 1989. Other ratios such as that of FAO (with N:P ratios of 1:1 and 1:0.72) fall within this range.

Figure 16

THE RECOMMENDED POTASH DEVELOPMENT STRATEGY

I. PREPARATORY PHASE BY THE YEAR 2000



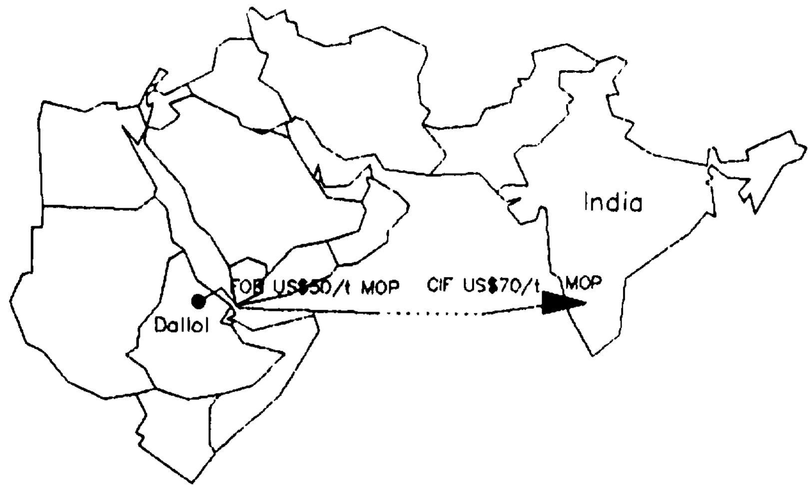
a) Establishment of pilot–scale industrial facilities (25.000 tpy K_2O) in order to prepare a diversified potash production programme for export, at the same time satisfying Ethiopia's needs for MOP/SOP.

b) Connection to hydroelectricity grid; utilization of both solar and geothermal energy in pilot–scale production.

c) Searching for an optimum location for a potash export terminal; improving Mersa Fatma Rail link and Dallol air strip.

d) Detailed feasibility and market study for an industrial–scale potash complex in Ethiopia.

II. LONG–TERM SCENARIO BEYOND THE YEAR 2000



Enhancements

1. Good quality potash ore
2. Close access to Red Sea shore
3. Geothermal and solar energy

Constraints

1. Overcapacity in the world potash industry
2. Depressed potash prices
3. Thailand and China have their own potash facilities
4. Limited market in South–East Africa

Viability condition

Price competitiveness at the Indian market

The Government programme is thus characterised by low nitrogen demand and a high phosphate gap, while the UNIDO programme is characterised by a high nitrogen demand and a low phosphate gap in the year 2005. It is the development strategy for the nitrogen fertilizer sub-system that most differentiates the Government and UNIDO programmes.

The undeveloped phosphate raw material base (P+S) prohibits quantitative analysis of any production increases in terms of P2O5 in both options. Domestic production of potash (23,000 tpy of K2O in the UNIDO programme), is not included in the Government programme as the N:K ratio is here 1:0.

Table 20 illustrates FERTIS development in 1989 and Government and UNIDO targets for the year 2005.

The Government programme envisages:

- Construction of an ammonia-urea (nitric acid) complex with a capacity of 450 TPD of A and 765 TPD of U in Gode (phase I of a nitrogen industry programme). A natural gas pipeline (100 km) will be built from Calub to Gode, and a 600 km road from Gode to Shashemane will be improved in order to supply urea to cereal growing areas in the highlands.

  It is assumed here, and not in Government plans, that construction of an ammonia-nitric acid-ammonium nitrate-calcium ammonium nitrate complex would complement the plant at Gode. This complex would have a capacity of 150 TPD of A, 300 TPD of NA and 500 TPD of AN/CAN. The complex would produce ammonia by electrolysis of water and might therefore be located in the vicinity of a hydropower plant at Finchaa.

- Development of domestic deposits of phosphate rock in Ogaden (apatite in Wollega) and sulphur (pyrites in Asmara) in order to lay a foundation for establishment of a phosphate fertilizer industry. Due to insufficient data this phase has not been quantified in terms of investment needs.

- Should the phosphate raw materials base be developed by the period 2000-2002 (a phosphate rock or apatite mine in Ogaden or Wollega), a nitrogen-phosphate fertilizer complex might be built. This investment is not quantified in this Integrated Programme.

- Development of domestic deposits of potash for an export oriented potash complex to be built after the year 2005. Hydroelectric, geothermal and solar energy schemes could be examined for open-pit solution mining, refining and production of potash. Phase III A of the Government programme has not been quantified.

- Should the viability of a PE-PP packaging unit be confirmed, imported fertilizers might be brought to Assab in bulk and packed on site. The investment required has not been quantified here.

The UNIDO programme envisages:

- Construction of an ammonia-urea complex with a capacity of 500 TPD of A and 800 TPD of U at Yirga Alem (Phase I A of the development of a nitrogen

Table 21: The Ethiopian Fertilizer Industrial System in 1989, and Government and UNIDO Targets for 2005

	FERTIS 1989	GOVERNMENT TARGET 2005	UNIDO TARGET 2005
GENERAL INDICATORS			
N:P:K ratio	1:1.56:0.03	1:1.35:0	1:0.5:0.06
NPK demand (tpy)	290,000	656,000	650,000
NPK production (tpy)	-	145,000	354,000
NPK gap (tpy)	290,000	511,000	296,000
NPK imports (tpy)	100,000	511,000	296,000
Import share in supplies	100%	78%	46%
Import p.a. (US$m)	60	307	178
Arable land (mln ha)	18.0	18.0	18.0
Fertil. rate (kg NPK/ha)	5.5	36.0	36.0
Cultivated land (mln ha)	7.0	8.5	8.5
Fertil. rate (kg NPK/ha)	14.0	76.0	76.0
Population (millions)	47	71	71
Fertil. rate (kg NPK/capita)	2	9	9
Total product supply (tpy)	170,000	1,260,000	1,230,000
Import share in supplies	100%	70%	38%
NITROGEN PLANT (TPD)			
Gode	-	A 450 + U 765 (+ NA 30)	-
NG Pipeline		100 km	
Metahara (A+U)	-	Status unknown	-
NG Pipeline			
Yirga Alem	-	-	A 500 + U 800
NG Pipeline			700 km
Mojo I	-	-	A 500 + U 800
NG Pipeline			300 km
Mojo II (or Debre Markos)	-	-	A 500 + U 800
NG Pipeline			None (or 300km)
Finchaa (Tissisat)	-	A 150 + NA 300 + AN/CAN 500	---
PHOSPHATE PLANT (TPD)			
Assab (DAP+TSP)	-	Abandoned	Abandoned
POTASH PLANT (TPD)			
Dallol	-	Postponed (*)	MOP/SOP 150
RAW MATERIALS			
ETHIOPIA	-		Development of P, S, Ca, Mg, Micronutr.

(*) The export-oriented industrial-scale potash fertilizer complex at Dallol has been postponed. An MOP/SOP pilot-scale plant of 150 TPD capacity could have been included in the Government programme, were it not for the N:K ratio of 1:0.

fertilizer industry). A natural gas pipeline (700 kms) would be built to connect the gas field at Calub with major cereals and coffee growing areas.

- Construction of an ammonia-urea complex in Mojo with a capacity of 500 TPD of A and 800 TPD of U (Phase I B of a nitrogen fertilizer industry development). An additional 300 km segment of the natural gas pipeline would be built to connect Yirga Alem with Mojo.

- Construction of a second ammonia-urea complex in Mojo with a capacity of 500 TPD of A and 800 TPD of U (Phase I C of nitrogen fertilizer industry development). No natural gas pipeline would have to be extended, since the gas connection to Mojo would be provided in Phase I B. This option has been quantified in terms of investment.

  An alternative option in Phase I C is that of locating a third A/U complex in the Debre Markos area. This option would facilitate the best urea distribution pattern in the highlands, but would also require construction of a further 300 km segment of the natural gas pipeline from Mojo to Debre Markos, thus increasing the total investment cost of the programme. This option has not been quantified in terms of investment.

- Construction of a sulphuric acid plant based on imported sulphur and an ammonium sulphate plant in Mojo with a capacity of 200 TPD of SA and 250 TPD of AS (Phase I D of FERTIS development). Efficient operation of the two A/U complexes in Mojo would give sufficient ammonia for investment in an AS plant. 20,000 MTPY of elemental sulphur (brimstone) would have to be imported to feed the SA plant in Mojo, if domestic sulphur bearing raw materials were not then developed.

  This option would depend on the final location of the third A/U complex (Mojo or Debre Markos) as well as the degree of development of local sulphur related raw materials. This option is thus not quantified in investment terms.

- Development of domestic deposits of phosphate rock in the Ogaden (apatite in Wollega) and sulphur (pyrites in Asmara) in order to lay a foundation for the establishment of a phosphate fertilizer industry (Phase II A of the programme). This option is not quantified in terms of investment.

- Should a phosphate raw materials base be developed by the period 2000-2002 (a phosphate rock or apatite mine in Ogaden or Wollega), a nitrogen-phosphate fertilizer complex may be considered in order to decrease dependence on imports/grants of fertilizers (Phase II B of the programme.

- Development of domestic deposits of potash in order to prepare an export oriented potash complex to be built after the year 2005 (Phase III A of the programme). A pilot-scale potash plant with a capacity of 150 TPD of MOP/SOP is envisaged for Dallol so as to meet domestic demand for potash. Hydroelectric, geothermal and solar energy schemes would be examined for use in open-pit solution mining, refining and production of potash. Phase III A of the UNIDO programme has been quantified in terms of investment.

- Development of a small-scale bulk-blending plant with a capacity 20,000 tpy to match specific needs of Ethiopia's horticulture and agriculture for different fertilizer blends, including micronutrients (Phase IV A).

- Development of secondary nutrients (Ca, Mg - limestone and dolomite for liming acidic soils), as well as the micronutrients Zn, Cu, Fe, Mn, Mo, Bo and Co (Phase V A and V B). These activities have not been quantified in detail.

In addition to the above, a number of activities connected with engineering, energy, and transport are envisaged in the UNIDO programme. These are described in section 3.

There are important similarities between the two programmes. In both programmes the total nutrients delivered to soils in the year 2005 would amount to around 650,000 MTPY of NPK, with a resulting N:P:K ratio of 1:1.35:0 in the Government programme and 1:0.5:0.06 in the UNIDO programme. Total fertilizer product delivered to soils would amount to about 1.25 million tpy (1,260,000 tpy and 1,230,000 tpy in the Government and UNIDO programmes respectively).

Both programmes would improve conditions for a reduction of malnutrition, and improve foreign exchange generation from exports of cash crops.

Important quantitative differences between the two programmes are illustrated in Table 22.

2.8 Evaluation and Selection of a Preferred Programme

2.8.1 Selection of a Preferred Programme

The following six major criteria have been considered in the evaluation of the two alternative programmes:

(1) The contribution of domestic fertilizer production to nutrient demand by the year 2005. This is equivalent to 22% and 54% in the Government and UNIDO programmes respectively. Conversely, dependency on imports/grants of fertilizer is 78% and 46% respectively in the Government and UNIDO programmes. Thus, on this criterion the UNIDO programme is preferred.

(2) Absolute investment requirements for both programmes and the investment required per ton of NPK produced are major criteria in selecting a preferred strategy.

Investment decisions on the FERTIS cannot be made prior to feasibility and other study work. With this important qualification, Table 23 presents indicative figures on the proposed plants, levels of nutrient production and investment outlays required in both programmes. These figures relate only to those phases that have been quantified.

Table 23 shows that the total investment requirement of the Government programme is either US$ 507 million or US$ 351 million, depending on whether improvement of the Gode - Shashemane road is included in the programme or not. No investment is assumed in electricity generation. The investment required for the UNIDO programme is US$ 930 million. However, the investment required per ton of nutrient is lower in the UNIDO programme (US $ 2,630 /ton NK compared with US $ 3,500 /ton N in the Government programme).

Table 22 Important Indicators of the Government and UNIDO Programme

Indicator	GOVERNMENT PROGRAMME	UNIDO PROGRAMME
Capacities of plants (TPD)		
Ammonia capacity	450 + 150 = 600	3 x 500 = 1500
Urea capacity	765	3 x 800 = 2400
Calcium ammonium nitrate	500	---
Mop/Sop Pilot plant	---	150
Length of NG pipeline (km)	100	1000
Power requirements for Water electrolysis (MW)	60	---
Major road improvements (km)	600	---
Structure of supplies - Fertilizer products(tpy)		
Domestic:	380,000	760,000
Urea	226,000	720,000
AN/CAN	154,000	---
MOP/SOP	---	40,000
Imports:	880,000	470,000
Urea	60,000	---
DAP	600,000	450,000
TSP	220,000	---
Blends with micronutrients	---	20,000
Total:	1,260,000	1,230,000
Import share in supplies:	70%	38%

If improvement of the Gode-Shashemane road is not included in the Government programme, the investment required per ton of nutrient is similar in both programmes (US $ 2,420 /ton N and US $ 2,630 /ton NK in the Government and UNIDO programmes respectively). No investment is assumed in the Government programme for the Finchaa hydropower station. If any investment were needed for the Finchaa hydropower plant, the investment per ton of nutrient produced in the Government programme would grow correspondingly. No assumption has been made regarding the possible use of by-product oxygen resulting from the electrolytic production of ammonia in Finchaa.

In summary, investment requirements are much higher in the UNIDO programme. Specific investment costs per ton of nutrient produced do not differ much between the two options. The Government programme is preferred on criterion (2).

(3) A very important consideration is the cost of delivering fertilizer to cropping areas in the highlands, where 90% of the population live. As illustrated in section 1.1.3 (f), the cost of handling and transporting imported fertilizers from Assab to stores in Nazreth, Mojo and Addis Ababa is equivalent to approximately US$ 100 per ton of fertilizer product. Similar transport costs would have to be borne to deliver urea from Gode to the highlands, especially if the Gode-Shashemane road is not improved.

Table 23 Investment Proposals of the Government and UNIDO Programme

Phase	Location	Plants / Infrastructure	Investment (US$m)	Nutrients (000s tpy)	Spec. Inv. (US $/1 t)
Government Programme					
I	Gode	A+U	226		
		NG Pipeline (100 kms)	30		
		Road improv.(600 kms)	156		
		Total	412	105 N	3,920
		Total without road improv.	256	105 N	2,440)
I A	Finchaa	A+NA+AN/CAN	90		
		Electricity connection	5		
		Total	95	40 N	2,375
		Programme total	507	145 N	3,500
		Total without road improv.	351	145 N	2,420)

Phase	Location	Plants / Infrastructure	Investment (US$m)	Nutrients (000s tpy)	Spec. Inv. (US $/1 t)
UNIDO Programme					
I A	Yirga Alem	A+U	200		
		NG Pipeline (700 kms)	210		
		Total	410	110 N	3,720
I B	Mojo I	A+U	200		
		NG Pipeline (300 kms)	90		
		Total	290	110 N	2,640
I C	Mojo II	A+U	200	111 N	1,800
III A	Dallol	MOP/SOP (Pilot Plant)	30	23 K20	1,300
		Programme total	930	354 NK	2,630

Fertilizer delivery costs to main agricultural areas are compared in Table 24. The comparison assumes a delivery cost for imported fertilizer of US$ 100/ton, a delivery cost for 80 per cent of the urea from Gode (180,000 tpy) of US$ 100/ton, and a delivery cost of US$ 10/ton for urea and CAN produced in Yirga Alem, Mojo and Finchaa.

On the delivery cost criterion the UNIDO programme has a distinct advantage, at US $ 47.3/ton of product as against US $ 85.7 /ton of product in the Government programme. This implies an annual saving in delivery costs of about US $ 50 million in the UNIDO programme. Over 15-25 years, the average life-span for fertilizer plants, the difference in delivery costs would by itself cover the higher investment in the UNIDO programme. By contrast, the Government programme would also require substantial investment in the Gode-Shashemane road.

Table 24: Cost of Fertilizer Deliveries to Ethiopia's Main Agricultural Areas

Source of Delivery	Cost of fertilizer delivery - Government Programme (million US$ per year)	Cost of fertilizer delivery - UNIDO Programme (million US$ per year)
Domestic:	20.00	11.20
Urea	18.46	7.20
AN/CAN	1.54	---
MOP/SOP	---	4.00
Imports:	88.00	47.00
Urea	6.00	---
DAP	60.00	45.00
TSP	22.00	---
BLENDS	---	2.00
Total:	108.00	58.20
Net difference:	- 49.80	00.00
Cost per ton:	85.70	47.30

In summary, the delivery costs of fertilizer to main cropping areas, and hence the potential competitiveness of domestically manufactured fertilizers compared with landed costs of fertilizers from international markets, gives a clear advantage to the UNIDO programme.

(4) A time advantage, due to an advanced stage of planning the first phase of the programme (Gode), favours the Government programme. However, due to a longer planning horizon the UNIDO programme has a number of advantages. Thus, criterion (4) does not strongly favour either programme.

(5) The N:P:K ratio of 1:0.50:0.06, assumed in the UNIDO programme, is believed to be more appropriate for long-term strategies than that of the Government (1:1.35:0). Given an expected rise in the phosphate content of the soil due to continuous fertilization with DAP, the N:P:K ratio of the UNIDO programme better accomodates the expected shift in nutrient application over the coming 15 years. The N:P:K ratio assumed in the UNIDO programme is closer to the latest FAO estimate (N:P of 1:0.72). This N:P:K ratio is also in line with present trends in Africa (1:0.75:0.37) and in developing countries generally (1:0.35:0.14), as well as by the fact that surpluses of potash are reported in major Ethiopian soils. Criterion (5) is of great importance in the design of an appropriate strategy for the FERTIS.

(6) The use of a systems approach use to design a comprehensive Integrated Development Programme is likely to facilitate sustainable development of the FERTIS within the Ethiopian economy. In this sense, the UNIDO programme more closely addresses the overall requirements of the FERTIS.

Four of the above criteria favour the UNIDO programme. However, it is recommended that both programmes be pursued until TA project 6 is implemented (a seminar on NPK demand and the optimum N:P:K ratio).

In addition to the main criteria discussed above there are a number of additional points which tend to favour adoption of the Integrated Development Programme presented in this document. These further considerations are detailed in the next section.

2.8.2 Additional Considerations Favouring Selection of the UNIDO Programme

Additional points to consider in favouring the UNIDO programme are as follows:

(a) The UNIDO programme facilitates a higher attainment of the Government's food self-sufficiency target. The UNIDO programme secures as much as 54 per cent of agriculture's nutrient demand by the year 2005.

(b) Due to a larger domestic production of fertilizers and a more complex fertilizer distribution pattern, the UNIDO programme better addresses Ethiopia's second priority goal of foreign exchange generation, through increased exports of coffee and other cash crops.

(c) The UNIDO programme is based on domestic raw materials (natural gas and potash ores) and aims on the one hand at substantial import substitution of nitrogen fertilizers (lessening dependency on imports and grants) and on the other hand at exports of potash fertilizers.

(d) The UNIDO programme assumes a shift of the N:P ratio to that recommended by the IAR (1:0.5), giving priority to nitrogen. Thus, ammonia and urea would be the backbone of the FERTIS development strategy.

(e) Three intermediate-scale ammonia-urea complexes would still exploit scale economies and help justify construction of a natural gas pipeline between Calub and Addis Ababa. Standardization of equipment and spare parts, as well as training of staff, could be optimized. Three ammonia-urea complexes built in phases would allow gradual absorption of urea in line with growth in demand.

(f) The UNIDO programme gives flexibility through phased planning and investment. The programme envisages a natural gas pipeline to be built in two phases, which may be necessary due to limited foreign exhange availability.

(g) The south-west route of the natural gas pipeline from Calub to Addis Ababa provides better locations for nitrogen fertilizer complexes in Phase I (Yirga Alem area) and Phase II (Mojo) in terms of fertilizer distribution. This is because cropping areas are located in the Ethiopian highlands, mostly in Shewa, Arsi, Keffa and Gojam. Mojo is also located near central fertilizer stores. Main roads also meet here with the only railway connecting the port of Djibouti and Addis Ababa.

(h) The UNIDO programme offers a complex plan leading to development of indigenous phosphate related raw materials (phosphate rock/apatite and zinc/copper pyrites) so as to lessen the almost total dependency on imported phosphate fertilizers. The UNIDO programme accords with future plans to develop a nitrogen-phosphate and phosphate fertilizer industry in the Ogaden and/or Wollega region.

(i) The establishment of a pilot-scale potash plant at Dallol is important for developing links between the potash and nitrogen-phosphate industry, and for preparing future investment decisions on an export oriented world-scale potash complex in Ethiopia.

(j) This programme also aims at developing secondary nutrients (S, Ca, Mg), as well as the micronutrients Zn, Cu, Fe, Mn, Mo, Bo and Co.

(k) Phased investment accompanied by infrastructure development act as an important response to the transport/distribution constraint as well as to the problem of a limited foreign exchange availability. The UNIDO programme is less dependent than the Government programme on access to the Red Sea ports.

(l) Phased implementation of this programme is set against the target year of 2005. The scheduling of the programme can be adjusted. Events may be such that the programme better suits the timeframe 1992-2010.

(m) Apart from directly addressing development of the fertilizer industry, twenty technical assistance projects making up this Integrated Development Programme relate to transport, infrastructure, energy, the environment, engineering industries, small-capacity bulk blending and packaging industry development. Two groups of projects aim at strengthening national capabilities in coordination, investment planning, staff and management training, procurement and trade, as well as the design of policy measures.

2.9 Expected End-of-programme Situation

Successful implementation of the UNIDO programme would allow 54 per cent of projected imports of fertilizers to be substituted by domestic production. Foreign exchange savings and earnings would be derived from:

- Import substitution of urea from Yirga Alem and the stimulation of exports of coffee through the domestic supply of urea. At the same time, urea would be delivered to cereals cropping areas in Arsi and Keffa, thus substituting imports/grants of grain.

- Two ammonia-urea complexes at Mojo delivering fertilizers to the highlands and substituting imports of urea.

- The Dallol MOP-SOP plant delivering potash fertilizers for domestic use.

- In addition, all important activities involved in the FERTIS, from transport to policy design, training, equipment manufacture and others, would be strengthened and, where necessary, created.

Table 25 illustrates the expected development of the FERTIS by the year 2005 following successful implementation of this Integrated Programme.

Table 25 Expected FERTIS Development through the UNIDO Programme by 2005

OBJECTIVE	PHASE	TIME-FRAME	LOCATION	DESCRIPTION
FERTIS Preparation	0	1992-1995	Ethiopia	Implementation of FERTIS 20 TA projects.
NITROGEN				
	I A	1996-2000	Yirga Alem	Construction of the first A/U complex + NG Pipeline.
	I B	2000-2003	Mojo	Construction of the second A/U complex + NG Pipeline.
	I C	2003-2005	Mojo	Construction of the third (DebreMarkos) A/U complex.
	I D	Beyond 2005	Mojo	Optional Construction of a SA + AS complex based on brimstone and local ammonia.
PHOSPHATE				
	II A	1992-2000	Ethiopia: Ogaden Wollega Asmara	Development of the P+S raw material base. Establishment of phosphate and pyrite mines.
	II B	1999-2004	Ogaden, Wollega	Construction of a phosphate complex to produce A+NA+SA+PA+TSP+DAP+NP (Gode).
POTASH				
	III A	1995-2002	Dallol	Development of potash ores, construction of a pilot- scale MOP/SOP plant and optimization of the system to prepare an export oriented potash project in Ethiopia.
NPK				
	IV A	1996-1998	Assab	Construction of a small-scale bulk-blending unit to match specific needs of agriculture and horticulture in Ethiopia.
SECONDARY NUTRIENTS + MICRONUTRIENTS.				
	V A V B	1996-2004	Ethiopia	Development of industrial schemes for the application of secondary nutrients and micronutrients in agriculture.

Table 25. cont.

OBJECTIVE	PHASE	TIME-FRAME	LOCATION	DESCRIPTION
ENGINEERING				
	VI A	1995-2005	Ethiopia	Implementation of programmes aimed at supplying simple equipment and spare parts to FERTIS facilities.
ENERGY				
	VII A VII B	1995-2005	Ethiopia	Development of industrial schemes for utilization of hydroelectric, geothermal
	VII C			and solar energy for the FERTIS in Ethiopia.
TRANSPORT				
	VIII A	1995-1997	Gojam, Shewa	Construction of two FERTIS stores at Debre Markos and at Debre Birhan for AISCO.
	VIII B	1996-1998	Ethiopia	Expansion of the packaging industry (Assab) to match for bagged fertilizers.
	VIII C	1995-2005	Ethiopia	Transportation of critical equipment by air to FERTIS construction sites.
	VIII D	1998-2005	Ethiopia	Technical programmes aimed at timely spreading of granulated fertilizers to remote rural areas and villages.

3. THE INTEGRATED DEVELOPMENT PROGRAMME

3.1 Programme Objectives

This Integrated Development Programme for the FERTIS in Ethiopia aims at:

- Defining long-term objectives and strategies for the creation of a domestic fertilizer industry in Ethiopia.
- Defining major agricultural targets for appropriate planning of FERTIS development so as to improve national food self-sufficiency.
- Strengthening the Government's capability in planning, policy design and coordination of development in the fertilizer industry.
- Assisting rational utilization of FERTIS related natural resources and national energy potential.
- Assisting Ethiopia to begin a process of fertilizer import substitution based on domestic raw materials, primarily involving production of nitrogen, but also including potash fertilizer.
- Assisting ELMICO in promoting a potash export oriented project, especially in relation to pilot-scale industrial facilities.
- Assisting environmental protection in relation to the fertilizer industrial system.
- Strengthening capabilities of the Ministry of Industry and the National Chemical Corporation in planning investment, selecting technological processes and economic options in FERTIS development.
- Strengthening the capabilities of AISCO in procurement, trading and logistics.
- Defining a package of training programmes aimed at preparing engineering staff for investment in, operation and maintenance of FERTIS plants and facilities.
- Assisting the Government to attract finance from international agencies and donor organizations for the implementation of the technical assistance component of this Integrated Programme.

Table 26 outlines the system components, the main system constraints, on-going actions, and the proposals of this Integrated Development Programme to ameliorate these constraints.

Table 26 System Components, Constraints and Proposals of the Integrated Development Programme

Component	Constraint	Programme Proposals
A. Natural Resources		
Natural gas utilization	Natural gas field located in remote area. Lack of funding for NG development.	Implementation of NG development schemes through pipelining NG to A/U complexes located in cropping areas - TA 8 and 9.
Water, hydroelectricity	High cost of water electrolysis to ammonia	Location of ammonia plant proposed near the hydropower plant at Finchaa.
Phosphate and sulphur R.M.	Limited development of mining sector. Lack of finance for feasibility studies.	Feasibility studies on raw materials - TA 11 10, 14 and 15.
Secondary nutrients and micronutrients	Limited development of mining sector and low awareness of the benefits of secondary and micronutrients.	Survey of limestone/dolomite for liming soils; survey of micronutrients - TA 11
B. Processing to Intermediates	Ammonia, phosphoric and nitric acids not yet manufactured.	Ammonia plants planned at Gode, Yirga Alem, Mojo, and Finchaa - TA 7,8 and 9. Nitric acid plant at Finchaa. Phosphoric acid plant depends on development of phosphates - TA 11
C. Processing of NPK fertilizers	Not yet developed, despite many previous plans.	Food self-sufficiency strategy supports construction of urea, CAN, MOP/SOP plants at Yirga Alem, Mojo, Finchaa, Dallol - TA 9, 14
D. Other operations	There is no bulk blending unit in Ethiopia. Only bagged fertilizer is imported.	Plans for construction of a small-scale bulk blending unit in Assab - TA 17. Expansion of the domestic packaging industry - TA 18.
E. Energy self-sufficiency and per capita energy consumption	Despite abundant energy potential (hydro and geothermal) and huge gas deposits, limited development of the energy sector causes deforestation (fuel gathering), aggravating soil erosion.	FERTIS will substantially contribute to the development of NG utilization schemes and networks of hydroelectricity and geothermal energy - TA 8,9, 14 and 15

Table 26 (contd.)

Component	Constraint	Programme Proposals
F. Storage, transport and distribution	Limited access to the Red Sea ports. Insufficient modern storage facilities at Assab port and elsewhere. Poor quality of roads and insufficient road network cause delays in fertilizer supply and damage to product during distribution.	Creation of a domestic fertilizer industry will substantially reduce fertilizer traffic in the ports of Assab and Djibouti. Imports and grants of grain will also diminish. Selection of proper locations for FERTIS complexes will improve distribution and reduce fertilizer delivery times. New fertilizer stores in Shewa and Gojam will improve the situation - TA 5 and 19
G. Fertilizer consumption	Consumption of fertilizer is limited because of an inappropriate crop/nutrient ratio, low rate of fertilizer adoption by farmers, inadequate extension services and limited distribution capacities. Only DAP and urea are used. No secondary or micronutrients are used.	TA 4 addresses policy in FERTIS. TA 5 aims at expansion of FERTIS stores. TA 6 aims at defining optimum fertilizer types and grades. TA 11 aims at development of secondary nutrients and micronutrients. TA 17 aims at supplying various fertilizer blends with micronutrients for specific uses.
H. Demand for fertilizer in the year 2005	There are several different estimates on optimum fertilizer demand and the N:P:K ratio by the year 2005. Fertilizer demand is expected to grow sixfold. This volume will be severely constrained by access to Red Sea ports and their unloading/reloading capacities.	A joint UNIDO/FAO seminar, TA 6, addresses issues of NPK demand, the N:P:K ratio and fertilizer types/grades. Creation of a domestic FERTIS will relieve traffic in Red Sea ports. TA 5 aims at storage expansion.
I. Fertilizer application	Only DAP and urea are used at present. Complex NPK fertilizers, secondary nutrients and micronutrients will have to be applied if yields are to grow substantially by 2005	TA 6 concerns the affinity of local soils and crops to fertilizers used. TA 17 will further this work. TA 15 aims at combined production of MOP/SOP and KMgS to be tested in Ethiopian soils.

Table 26 (contd.)

Component	Constraint	Programme Proposal
J. Fertilizer impact on agricultural production	Limited FERTIS development is a severe constraint on increases in crop yields and agricultural production. Limited inputs to agriculture, and soil erosion, threaten the food base of future generations in Ethiopia.	The whole TA package aims at accelerating development of the FERTIS. FERTIS is to contribute to production of about 4 million tpy of grain by 2005 and to increased exports of cash crops (coffee)
K. The incentive to farmers to use fertilizers	Inadequate crop to fertilizer price ratio. Lack of subsidy on fertilizers and risk in applying fertilizers by farmers. Insufficient awareness of benefits from proper use of fertilizers. Misuse of fertilizers.	Policy design in FERTIS, TA 4. addresses these constraints. The more competitive FERTIS will be on world markets the more incentives can be offered to farmers: TA 1 addresses overall coordination of FERTIS with national plans and goals.
L. Government priority in FERTIS	Insufficient information for appropriate policy formulation in FERTIS development.	TA 1 addresses overall coordination of FERTIS development with national plans and goals. Management of industrial planning is addressed by TA 3.

3.2 Technical Assistance Projects

Twenty technical assistance and investment projects are proposed to implement this Integrated Development Programme. These projects are listed and briefly described below and their foreign exchange costs given.

TA 1. Overall Coordination of the FERTIS Development Programme with National Plans and Goals (US $ 40,000).

The implementation of an integrated development programme for FERTIS requires coordination with national plans and goals. To this end, the project aims to establish a FERTIS coordinating office within the Ministry of Industry (MOI). A FERTIS Steering Commitee, located in the MOI under the Vice Minister of Industry would be supported from the coordinating office. The Steering Commitee would be organised at the national level to promote FERTIS development, secure sufficient investment allocation in Government plans, mobilize external assistance for the programme, and provide relevant institutional and policy support. The project would be on-going throughout the implementation of this Integrated Development Programme.

TA 2. A Donors and International Agencies Conference on Technical Assistance Projects for the FERTIS Development Programme in Ethiopia (US $ 70,000)

Timely and successful implementation of the FERTIS technical assistance projects depends on the availability of finance. This project aims to invite donor organizations, international agencies and financial institutions to a presentation of the major objectives, targets and strategies contained in the Integrated Programme. These agencies would include the EEC, donor country organizations, the African Development Bank, the World Bank and UNDP. The Conference would aim to secure a commitment to finance the FERTIS technical assistance projects. A programme abstract and action plan will be sent in advance to all invited organizations. The Ministry of Industry, representing the Government of Ethiopia, and UNIDO, representing the UN system, would organize this Conference at the earliest date possible. The Conference would be held in Addis Ababa.

TA 3. Management of Industrial Planning for FERTIS (US $ 30,000)

The aim of this project is to train staff from the Ministry of Industry in issues of FERTIS planning and monitoring techniques. This training is of particular importance given the current limited experience in FERTIS development as well as the new managerial demands imposed by implementation of this Integrated Development Programme.

TA 4. Policy Design in FERTIS (US $ 45,000)

A clear definition of the policies required to implement long-term strategies and objectives for FERTIS development is of key importance. This project aims to assess ongoing-policies and propose a policy framework to support the Integrated Development Programme. Policies in key areas will be analyzed and optimal policies suggested. The Steering Commitee, a multi-ministerial body located in the MOI, would be responsible for designing and proposing policies aimed at sustainable development of the FERTIS.

TA 5. Fertilizer Storage and Transport Development with Improvements to the Djibouti Port Facilities and the Mojo-Nazreth-Addis Ababa Railway System (US $ 1,351,000)

This project is of great importance to the FERTIS given the expected six fold increase in fertilizer demand over the next 15 years. With succesful implementation of this Integrated Development Programme up to 60 per cent of this demand may be met by the domestic fertilizer industry. However, limited access to the Red Sea ports at Assab and Massawa, and inadequate unloading and storage capacities in those ports, require that consideration be given to using the Djibouti-Addis Ababa railway system for complementary transportation of imported fertilizers. Two FERTIS stores in Gojam and Shewa are to be designed by AISCO during the first phase of implementation of this project. The second phase of the project, concerning the railway system, will depend on progress made in the establishment of a domestic fertilizer industry.

TA 6. Joint FAO/UNIDO Seminar on Fertilizer Demand Forecasts, Optimum N:P:K Ratios, and Optimum Types and Grades of Fertilizers (US $ 50,000)

This project provides a basis for designing long-term strategies of FERTIS development in Ethiopia. The project aims to co-ordinate the identification of FERTIS planning objectives and fertilizer demand levels. A joint UNIDO,FAO and IAR study may follow at a later stage. The Seminar should be one of the first activities of the Integrated Development Programme, providing investment and planning parameters for the remaining activities.

TA 7. Consultancy Services on an Ammonia-Urea Fertilizer Complex at Gode (US $ 400,000)

If the location of an A/U plant at Gode is chosen then the complex would be fully incorporated in this Integrated Development Programme. Continuous assistance will be provided from inquiry and bid evaluation to technical assistance for plant operation for one year after commissioning and start-up. The assistance will include assessment of contractors, preparation of technical appendixes to contracts, evaluation of contract technical documents, and the training of staff in the management, operation and maintenance of ammonia/urea plants.

TA 8. A Natural Gas Development Scheme for the FERTIS in Ethiopia (US $ 2,500,000)

This project is of great importance if a nitrogen fertilizer industry is to supply urea to the Ethiopian highlands on terms competitive with imports. An optimum route will be identified for a natural gas pipeline connecting the gas field at Calub with the highlands. An optimum capacity of the pipeline, including pipe diameter, gas pressure and necessary compression stages will be defined for the FERTIS and other industrial and non-industrial consumers. Suggestions relating to the price level of natural gas for the nitrogen fertilizer industry will be prepared. This project is directly related to projects 7 and 9.

TA 9. Techno-Economic Appraisal of an Ammonia-Urea Complex Located in a Cropping Area and Using Pipelined Natural Gas (US $ 100,000)

The project will determine the viability of locations for ammonia-urea complexes alternative to that at Gode. This assessment will take into consideration investment and operational costs, as well as the costs of distributing urea in main cropping areas. Technical assistance project 8 is complementary to this project, and successful implementation of both projects is a pre-condition for development of the nitrogen fertilizer industry.

TA 10. FERTIS Development, Environment Protection and Balanced Utilization of Natural Resources (US $ 155,000)

Growing consumption of fertilizers in Ethiopia requires pollution monitoring (especially for water contamination). Land degradation associated with mining of phosphate rock, pyrites, potash, dolomites and limestone may also pose environmental problems. The project aims at incorporating health and environmental safety measures in planning, implementation and operational aspects of FERTIS development. Through this project The Ethiopian Valleys Development Studies Authority will aim to support environmental protection through acceptance at the project level of sound, pollution-free technologies, through proper use of fertilizers and regular monitoring of risks to the population and ecology. The project includes a training component and will establish laboratory facilities for sampling and analysis of industrial effluents. Environmental impact assessment and awareness building on the proper use of fertilizers will also be undertaken through mass media.

TA 11. Feasibility Studies on Raw Materials for FERTIS Development (US $ 2,600,000)

The project involves surveying, mapping and exploration of apatite, phosphate rock, pyrites, limestone, dolomite and micronutrients (Zn, Cu, Fe. Mn, Mo, Bo, and Co) required to supply a fertilizer industry with raw materials. The most important investigations concern the phosphorous raw material base, as Ethiopia is dependent on imports and grants of phosphate fertilizers (DAP). Exploration of phosphate rock would lead in the long run to the establishment of a phosphate mine. A similar project is being considered for financing by the African Development Bank (ADB) for the period 1992-94. At the time of writing this project had not been accepted by the ADB. Exploration of secondary nutrients and micronutrients is expected to become increasingly important in the future.

TA 12. Development of University Programmes and Curricula to Prepare Engineers for the FERTIS (US $ 106,000)

This project will be co-ordinated by the Chemical Engineering Department of Addis Ababa University, although training will also include students of the Mechanical and Electrical Engineering Departments. The aim of the project is to assure proper training of graduates to staff fertilizer factories and companies in energy and mining sectors, domestic suppliers of equipment, design offices, laboratories and the fertilizer industry institute. The project will assure provision of necessary teaching materials, including flowsheets and models of principal unit operations and fertilizer processes, as well as computing and laboratory equipment to meet deficiences in the engineering courses. At least one training course in foreign fertilizer facilities is foreseen for selected students.

TA 13. Training for Engineers and Technicians at the Egyptian Fertilizer Center (US $ 60,000)

A future fertilizer industry in Ethiopia needs a pool of chemical, electrical, instrumentation, mechanical, and civil engineers and technicians. Training is required to assure efficient preparation of investments, construction and operation of fertilizer plants. At present there are no fertilizer plants in Ethiopia. Therefore, training programmes should be arranged in fertilizer factories outside Ethiopia, preferably in the Egyptian Fertilizer Center. This training will enable Ethiopia to increase the participation of the national workforce in the running of a fertilizer industry, a fact which will assume particular importance after expatriates are withdrawn following commissioning of FERTIS plants and facilities.

TA 14. Potash Exploration in Dallol, Ethiopia (Preparatory Phase) (US $ 3,000,000)

This project will result in a complete feasibility and domestic market study, supported by agricultural research, as well as assumptions for basic engineering and an investment plan for a 150 TPD MOP/SOP plant. The project will also complete feasibility work on establishing a 1.5 million MTPY open pit/solution mine and beneficiation facilities yielding muriate of potash, sulphate of potash and other salts.

Given the large investment requirement and limited export market for potash, a preparatory phase for this investment is required. This preparatory phase aims at the establishment of pilot-scale industrial facilities (150 TPD) in order to work-out a diversified production programme for various potash and magnesium compounds for export. By the year 2000 a pilot-scale plant would supply domestic demand for potash and would be optimal in terms of investment and energy-saving (hydroelectricity, geothermal and solar energy). Before the second phase of the programme, a market study should compare the landed cost of Ethiopian potash in India, East Africa and elswhere with potash delivered from Europe, Canada and Jordan. Likewise, a detailed techno-economic analysis of project viability must precede the final investment decisions. This project is directly related to projects 6, 15 and 16.

TA.15. Geothermal Energy Utilization for FERTIS Development in Ethiopia (US $ 3,500,000)

Exploitation of Ethiopia's massive geothermal energy potential may substantially increase the competitiveness of a domestic fertilizer industry in international markets. Geothermal energy may be utilized for FERTIS as a power source and as direct heat (steam, hot water), especially for potash production (potash ores and geothermal potential are located in the Rift Valley in the Danakill Depression). This project will result in a pre-feasibility study on geothermal energy utilization for FERTIS development in Ethiopia. In addition to training national specialists in the use of geothermal energy, the project envisages selection of a pilot well-head turbine (4MW) to utilize steam from wells already drilled in Aluto-Langano.

TA.16. Technical Assistance to Firms Supplying Equipment to the Domestic Fertilizer Industry (US $ 242,000)

The capacities of some private and National Metal Works Corporation engineering workshops are not fully utilized. These capacities might be used to manufacture simple equipment and spare parts for the FERTIS (generally excluding those parts responsible for process performance). In this way pressure on resources of foreign exchange could be reduced and the fertilizer industry could become more efficient. The project includes the following activities: assessment of existing facilities and skills and equipment needs of fertilizer plants; information collection from foreign manufacturers of equipment on manufacturing processes, licensing arrangements, design criteria, testing and certification; identification of fertilizer plant equipment suitable for local manufacture; upgrading local skills in design, manufacture and quality control; preparation of a project document on the rehabilitation/expansion of engineering workshops for the local manufacture of equipment for the FERTIS.

TA. 17. Feasibility Study on a Small-Scale Bulk-Blending Unit in Assab (US $ 150,000)

Ethiopia Amalgamated Co. (a private company which dominated the procurement and handling of fertilizers in Ethiopia prior to the 1980's) owns a number of stores in Assab for bagged and bulk fertilizers. With the new market orientation of the Ethiopian economy. Ethiopia Amalgamated Co. is expected to re-enter fertilizer related activities (procurement, handling, bulk-blending and bagging of fertilizers). This project will prepare an action plan for the establishment of a small-scale bulk-blending unit in Assab with a capacity of 20,000 tpy. The plant will blend fertilizer nutrients and micronutrients according to the specific requirements of Ethiopian horticulture and agriculture. Assab may be the only practical location for the bulk-blending unit (adjacent to fertilizer stores), especially as the transportation of straight fertilizers and their blending in other locations would be costly. This project will result in a complete feasibility and domestic market study for producing blends with micronutrients. This project is directly related to projects 5, 6 and 20.

TA 18 A. Pre-feasibility Study on the Establishment of a PE/PP Fertilizer Packaging Unit in Assab (US $ 50,000)

The project aims to decrease the cost of imported bagged fertilizers, DAP and urea, through production of PE/PP bags and bagging of fertilizers imported in bulk. Fertilizer demand in the year 2005 is expected to reach 1.25 million tpy of product. Even after successful implementation of this Integrated Programme, imports of about 0.5 million tpy of fertilizer would be required. Depending on progress in FERTIS development, the capacity of the PE/PP fertilizer packaging unit in Assab may vary from 10 to 25 million bags per year, equivalent to about 2,700 to 6,800 tpy of processed PE/PP. This range of plant capacities will be analysed in the pre-feasibility study.

TA.18 B. Training for Packaging Industry Development (US $ 134,000)

Expansion of the packaging industry by 15 - 18 million bags may be justified. A complete techno-economic study to establish a PP bags factory was prepared for the National Textile Corporation in 1984 by P-E International Operations Ltd.. This investment was not realized due to lack of finance. The NTC aims to train its staff abroad in production of polypropylene bags and to secure transfer of technology and know how before investment in the PP factory takes place.

TA 19. Training Services for a DAP/TSP Complex in Assab (stand-by project) (US $ 50,000)

Given a high demand for imports/grants of diammonium phosphate (DAP), estimated in the range of 450,000-820,000 tpy by 2005, and with limited possibilities of creating a domestic phosphate industry, construction of a fertilizer complex in Assab based on imported ammonia and phosphoric acid is being considered. However, prices of ammonia and phosphoric acid do not favour this project at the present time. The question of access to the port of Assab is expected to be clarified by 1994. Given these constraints this project is treated as a stand-by and would be implemented should the situation change in favour of this option. The project includes strengthening of NCC's management in negotiation of contracts and long-term agreements on purchasing and counter-trading ammonia, phosphoric acid and phosphate rock.

TA 20. Training Programmes to Strengthen the Managerial and Operational Capability of the Agricultural Inputs Supply Corporation (US $ 451,000)

Marketing of fertilizers requires planning, technical and managerial skills to procure and deliver fertilizer of the proper quality and quantity at the right time, place and price. Depending on progress in FERTIS development, the Agricultural Inputs Supply Corporation (AISCO) may be responsible, by the year 2005, for annual procurement of fertilizer worth from US$ 150 million to US$ 375 million. The envisaged training would focus separately on the operation and maintenance of mobile fertilizer bagging units, procurement/contracting and trading of imported fertilizers, and the storage, transport and distribution of fertilizer. Training would be organized both in Ethiopia and abroad.

Summary of Technical Assistance Projects

The total cost of technical assistance in this Integrated Development Programme is approximately US$ 15 million. Almost US$ 12 million would be employed on projects relating to development of raw material (P+S+K) and the energy base (projects 8, 11, 14 and 15). Project documents are included in the second volume of this Programme.

The time schedule for implementation of this Integrated Programme is estimated at 48 months. Of the twenty technical assistance project proposals, twelve are directly or indirectly related to potential investments.

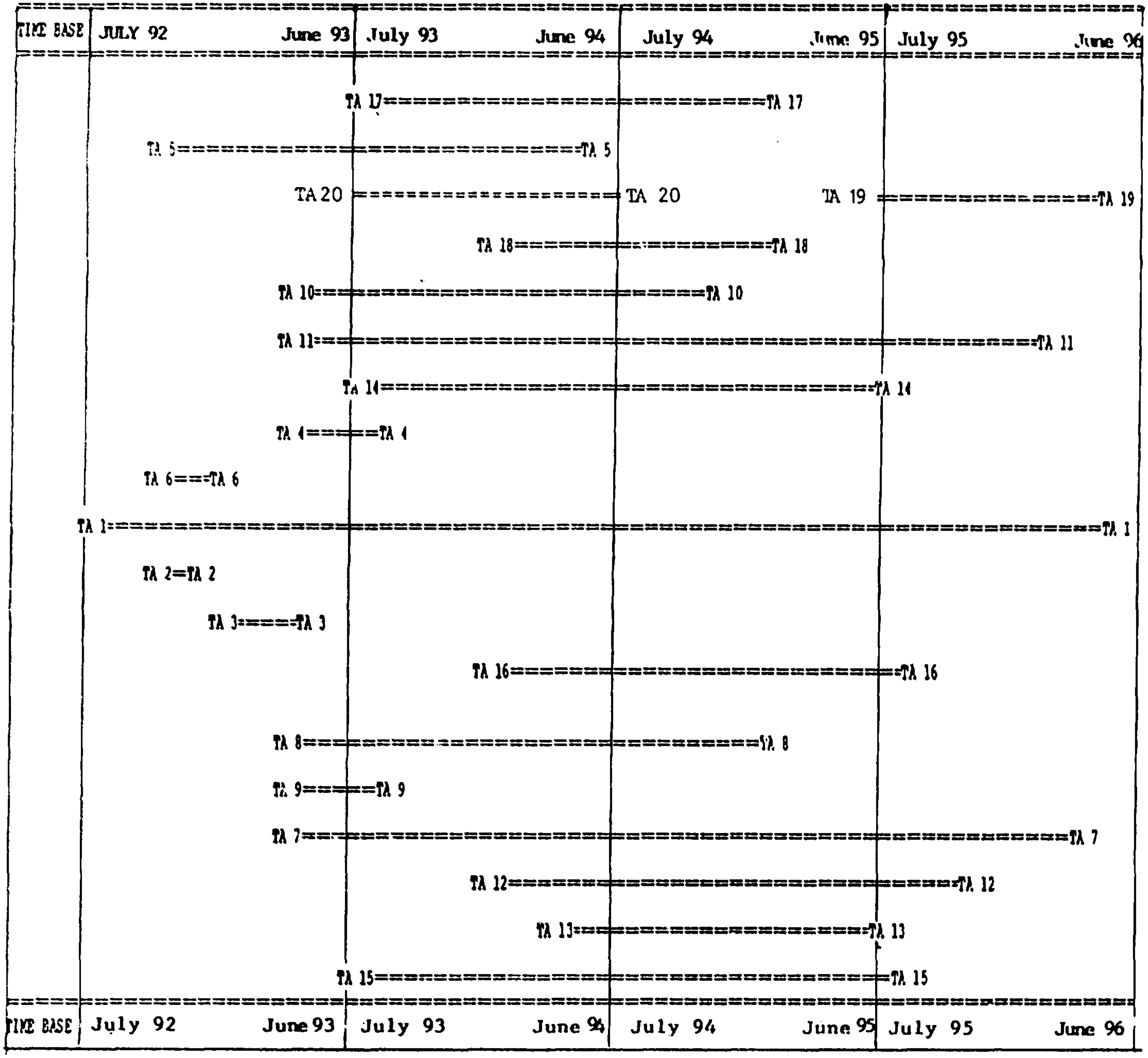
Project 1 relates to coordination of FERTIS development and would, through decisions of a Steering Commitee, govern the implementation of the whole package of twenty TA projects. Projects 2 and 6 are considered to be the most urgent as they relate to funding of the technical assistance package and a definition of optimum investment options and strategies, backed by proper policy measures.

It is difficult to specify an implementation schedule for the stand-by project (19) due to uncertainties surrounding access to the port of Assab and changes in prices of ammonia and phosphoric acid relative to DAP.

The implementation schedule for the technical assistance projects is seen in Table 27 below.

Table 27

IMPLEMENTATION SCHEDULE FOR TECHNICAL ASSISTANCE PROJECTS



A N N E X E S

Annex 1

UTILIZATION OF ETHIOPIA'S GEOTHERMAL POTENTIAL FOR FERTIS DEVELOPMENT

1992 is expected to see further exploration of Ethiopia's considerable geothermal energy potential, following the success of preliminary drilling programmes begun in the early 1980s around Lake Langano and Tendaho (financed by UNDP, the EEC and Italy).

Ethiopia's major geothermal energy resources are located in the Rift Valley area. A geothermal resource survey and further test drillings are yet to be completed in order to estimate in more detail Ethiopia's overall potential in geothermal energy. Indications are that this potential is large and can be estimated, in terms of capacity for electric power generation, as follows:

LOCATION	ELECTRIC POWER (MWE)	STUDY STATUS
Lake District	300	Detailed scientific study
Aluto Langano	30	Feasibility
Langano-Tendaho	1500	Reconnaissance
Tendaho	300	Pre-feasibility
Northern Afar	500	Reconnaissance
Danakil Depression	500	Reconnaissance
TOTAL ETHIOPIA	3130 MWE	

Despite the size of this potential it is doubtful if, in the long run, it can be competitive with large-scale hydropower systems.

Geothermal energy may be considered for a number of options in FERTIS development, especially because of the proximity of geothermal energy to deposits of fertilizer raw materials such as potash ore in the Danakil Depression. It is, however, as direct heat (geothermal steam, steam condensate and hot water) and not power that geothermal energy might be utilized in a most efficient way in many fertilizer processes, plants, and off-site FERTIS facilities.

The information gathered by the Geothermal Exploration Project from 8 wells located in the Aluto Langano area showed, among others, the following variability parameters:

- depth drilled — from 1300 to 2500 m;
- maximum pressure — from 35 to 65 bars;
- maximum temperature — from 83 to 335 oC;
- enthalpy — from 1000 to 1650 KJ/kg;
- total discharge (steam+water) — from 40 to 90 ton/hour.

These parameters show that geothermal energy fluids are mixtures of hot water/steam condensate and steam with a relatively low content of specific enthalpy, with especially high well pressures and temperatures, and having a high discharge volume, in particular of hot water.

This is is an indication that geothermal energy. because of its discharge volume. may find be used as a source of direct heat in many plants, especially those which use processes characterized by moderate and low temperature profiles.

It is obvious at the same time that several high temperature processes, i.e.the ammonia process, and heat exchange sections based on the condensation of high pressure steam will have to be excluded from the use of geothermal energy as a source of direct heat.

Use of geothermal energy for FERTIS development in Ethiopia may contribute to substantial decreases of the manufacturing costs of fertilizers.

TA project 15 directly adresses the issue of geothermal energy utilization forFERTIS development in Ethiopia. Several important questions relate to the utilization of geothermal energy in fertilizer plants and complexes, such as: the parameters of geothermal fluids in areas of geothermal potential, energy equivalents and values per unit of geothermal energy in those areas and the technical viability and economic effectiveness of connecting sources of geothermal energy to particular FERTIS plants. These and other questions should be answered by this Technical Assistance project.

Likewise, the efficiency of developing geothermal energy for the generation of electricity will have to be compared with that of hydroenergy.

Only if properly exploited to avoid depletion can geothermal potential be considered as a renewable source of energy in which the underground system or reservoir is recharged continuously.

Annex 2

AIR TRANSPORT FOR THE FERTIS IN ETHIOPIA

On Dec. 6th, 1991 the project team visited Ethiopian Airlines S.C. (EAL) in order to investigate possibilities of using air transport for:

- spreading granulated fertilizers from the air, which may be a very important option in remote regions where fertilizer cannot be delivered on time by road;
- transporting heavy and expensive equipment by air to FERTIS construction sites, an option for deliveries of key items of equipment.

From discussions with Mr. W. Girma, Director of Cargo Marketing, the project team learned that:

- within two years EAL will have aircrafts capable of spreading fertilizer from the air (pesticides were spread in a similar way). The volume of fertilizer to be spread from the air, estimated at about 20,000 - 30,000 ton per annum, could probably be accepted by Ethiopian Airlines;
- EAL can serve the Fertilizer Industrial System on a charter basis wherever there are airports (there are about 20 airports in Ethiopia). Five airports: Addis Ababa, Bahr Dar, Asmara, Dire Dawa and Gode can accomodate large jet-fuel planes. EAL is equipped with Douglas, Hercules, and Boeing 757 planes with a carrying capacity of 27, 28, and 38 tons respectively;
- a long air strip has already been built for a potential potash project in Dallol;
- Ethiopian Airlines does not need outside financial support for spreading fertilizers from the air or transporting critical items of FERTIS equipment by air.

EAL works on a purely commercial basis, and is ready to participate in the above-mentioned FERTIS-relating activities, provided it is approached well in advance in order to prepare for the timely execution of new tasks EAL would charge its new customers on a commercial basis.

VIABILITY OF MANUFACTURING NITROGEN FERTILIZERS FROM AMMONIA PRODUCED BY WATER ELECTROLYSIS

A nitrogen fertilizer complex (A/NA/CAN) based on the electrolytical route to ammonia could be located in the vicinity of the hydropower plant at Finchaa in order to complement the Government programme relating to an A/U fertilizer complex at Gode, without investing in a long natural gas pipeline from Calub to the highlands. Finchaa's competitiveness in terms of nitrogen produced is to be assessed, as follows:

A. AMMONIA PLANT. Capacity 150 TPD. On-stream Factor 1.0. Annual Production 50,000 t ammonia. Battery Limits cost US$50m. Total plant cost approximately US$55m, of which US$5m is for the hydroelectricity connection to Finchaa. Electricity costs of between US$20/MWh and US$10/MWh.

MANUFACTURING COST:	at 20 US$/MWh	at 10 US$/MWh
- Electricity 10 MWh/t A	200 US$/t	100 US$/t
- Personnel	6	6
- Maintenance	20	20
- Utilities	6	6
- Capital related costs at 15%	165 US$/t	165 US$/t
- Total Manufacturing cost	397 US$/t A	297 US$/t A

A 150 TPD ammonia plant at Finchaa would not be competitive in terms of manufacturing costs with natural gas based 500 TPD ammonia plants at Gode (220 US$/t) or in the cropping areas (265 US$/t) (UNIDO option). If, however, two NG based ammonia plants were built in the highlands, the ammonia plant at Finchaa could be competitive at an electricity price of 10 US$/MWh even assuming that no use is made of oxygen from the electrolytical route.

B. NITRIC ACID PLANT. Capacity 300 TPD. On-stream Factor 1.0. Annual Production 100,000 t of nitric acid. Battery Limits cost US$20m.

MANUFACTURING COST:	at 397 US$/t A	at 297 US$/t A
- ammonia 0.28 t/t	111 US$/t	83 US$/t
- operational costs	7	7
- steam credit	- 3	- 3
- maintenance	4	4
- capital related costs	30	30
- Total manufacturing cost	149 US$/t NA	121 US$/t NA

C. CALCIUM AMMONIUM PLANT. Capacity 500 TPD. On-stream Factor 0.92. Annual Production 154,000 t CAN. Battery Limits cost US$ 20m.

MANUFACTURING COST:		
- ammonia 0.163 t/t	65 US$/t CAN	48 US$/t
- nitric acid 0.587 t/t	87 US$/t CAN	71 US$/t
- CaCO3 0.26 t/t at 20 $/t	5	5
- operational costs	4	4
- maintenance	3	3
- capital related costs	20	20
- Total manufacturing cost	184 US$/t CAN	151 US$/t

Depending on the price of electricity, the manufacturing cost of calcium ammonium nitrate at Finchaa would be in the range of 151 - 184 US$/t CAN. Adding some 10 US$/t CAN for local supplies, one can assume a delivery cost of 160 - 195 US$/t CAN in the highlands.

CAN could be imported at a price of about 110 - 120 US$/t CIF Assab. This means that the landed cost of imported CAN in the Highlands would be about 210 - 220 US$/t. Hence, CAN produced at Finchaa would be competitive with imports, even at an electricity price of US$20/MWh.

However, of most importance is the calculation per ton of nitrogen supplied to the Highlands in CAN (26% N) and Urea (46% N), as follows:

- CAN from imports	808 - 846 US$/t N;
- CAN from Finchaa	615 - 750 US$/t N;
- Urea from imports	652 US$/t N;
- Urea from A/U complex at Gode	707 US$/t N;
- Urea from 3 A/U complexes	548 US$/t N.
- Urea from 2 A/U complexes	610 US$/t N;
- Urea from 1 A/U complex	767 US$/t N;

In terms of 1 ton of nitrogen delivered to the highlands, a fertilizer complex at Finchaa (A/NA/CAN) would be competitive with imports of urea and with urea delivered from an A/U complex at Gode only if the electricity price were between 10 - 12 US$/MWh.

A nitrogen complex at Finchaa would not be competitive in comparison with three urea plants built in the highlands and connected with a 1000 km NG pipeline. However, at an electricity price of US$10/Mwh, the effectiveness of the A/NA/CAN complex at Finchaa would be similar to that of two A/U complexes built in the highlands and connected by a 1000 km pipeline. At an electricity price of US$20/MWh a A/NA/CAN Finchaa complex will be competitive with a single A/U complex built in the highlands with a 1000 km NG pipeline.

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