THE FEASIBILITY STUDY REPORT
ON
THE ESTABLISHMENT OF A FUSED MAGNESIUM PHOSPHATE FERTILIZER PLANT
IN
THE REPUBLIC OF ZAMBIA

SEPTEMBER, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

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PREFACE

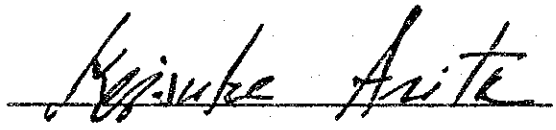
In response to the request of the Government of the Republic of Zambia, the Government of Japan has decided to conduct a feasibility study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Zambia a survey team headed by Dr. Shigeo Ueki, Japan Consulting Institute, from 23 November to 22 December, 1986.

The team had discussions on the project with the officials concerned of the Government of Zambia and conducted a field survey in the project-related areas. After the team returned to Japan, further studies were made and the present report has been prepared.

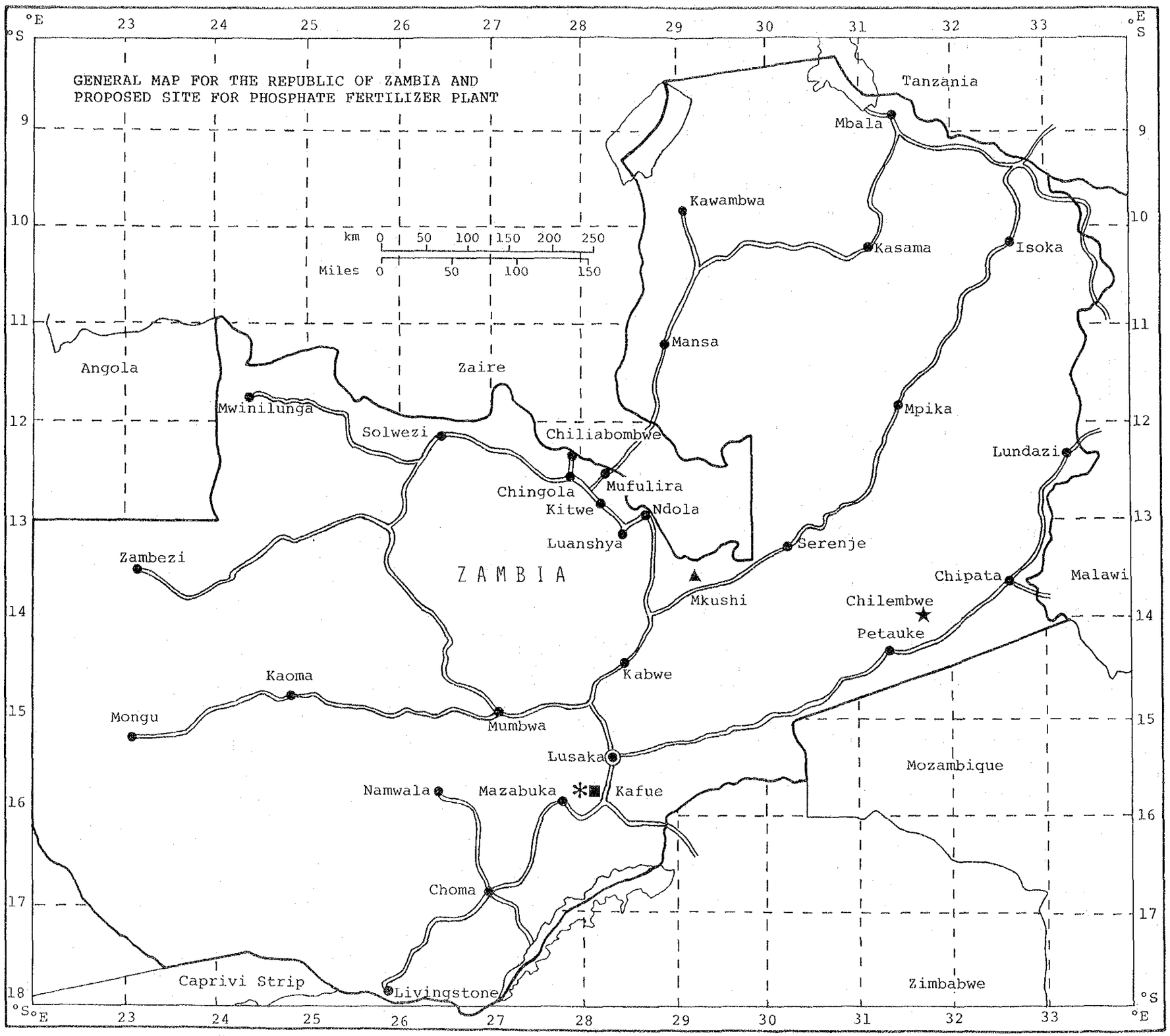
I hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Zambia for their close cooperation extended to the team.

September, 1987



Keisuke Arita
President
Japan International Cooperation Agency



Republic of Zambia

- Land Area : 753,000 km²
- Population : 6.88 Millions - 1986
  - Increase Rate : 3.1%/Year
- GDP/Capita : ZK1,759 - 1986
- Exchange Rate : ZK8.00/US$ - 1987

Reference Location for the Study Project

★ Chilembwe: Phosphate Reserve

- Ore Reserve : 1.55 Million Tons
- Ore Quality : 11.5% of P_2O_5
- Production Potential : Concentrate (30% P_2O_5, 35,181 TPY, 14 + years)
- Administration : MINEX, ZIMCO

▲ Mkushi: Serpentine Reserve

- Ore Reserve : 1.0 Million Tons
- Ore Quality : 32.8% of MgO (South Hill)
- Production Potential : Crushed Ore (32.8% MgO, 19,103 TPY, 32 + years)

■ Nitrogen Chemicals of Zambia Ltd. (NCZ), Kafue

- Ammonia : 96,000 TPY
- Nitric Acid : 120,000
- Sulfuric Acid : 60,000
- Ammonium Sulfate : 50,000
- Complex Fertilizer : 142,320
- Ammonium Nitrate : 140,000

✻ Proposed Site for Phosphate Fertilizer Plant: Southwest of NCZ Plant in Kafue

Plant Capacity:

- Fused Magnesium Phosphate : 50,400 TPY (20.11% C-P_2O_5)

or

- Single Super Phosphate : 57,205 TPY (17.20% Av-P_2O_5)

ABBREVIATIONS, ACRONYMS AND CONVERSION FACTORS

General

DCF	Discounted Cash Flow
Fiscal Year	January 01 to December 31 in Zambia
GDP	Gross Domestic Product
GNP	Gross National Product
IRR	Internal Rate of Return
ZK	Zambian Kwacha (ZK1.00 = Ngwe 100.0)
ROI	Return on Investment
ROE	Return on Equity
S/W	Scope of Work (INDECO-JICA, August 19, 1986)
The Study	The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia
The Cost Estimate Date	January 1, 1987 for the Study
MM	Million
MVA	Manufacturing Value Added
NPV	Net Present Value
Ngwe	Ngwe 100.0 = ZK1.00
US$	U.S. Dollar

Exchange Rates

- October 11, 1986	ZK5.01/US$	Weekly foreign exchange auction system (Marginal Rate) at BOZ
- January 1, 1987	ZK12.71/US$	Weekly foreign exchange auction system (Dutch Rate) at BOZ
- May 1, 1987	ZK8.00/US$	Fixed foreign exchange rate system at BOZ
- The Study	ZK8.00/US$	Prevailing prices level in Zambia is estimated on January 1, 1987 but the exchange rate of ZK8.00/ US$ is applied because of adjustment delay of domestic prices to foreign exchange rate fluctuation observed during the study period.

Organization and Others

BOZ	The Bank of Zambia
CAPC	Central Africa Power Company
CDA	Cattle Development Area
CFC	Cattle Financing Company
COZ	Credit Organization of Zambia
CPC	Copper Belt Power Company
CSO	Central Statistical Office
CSBZ	Cold Storage Board of Zambia
CSSL	Crushed Stone Sales Ltd./INDECO
DAO	District Agriculture Officer
DBZ	Development Bank of Zambia
DOM	Department of Meteorology
DPB	Dairy Produce Board
EOJ	Embassy of Japan
EF	Emergent Farmers
FAO	Food and Agriculture Organization
FD	Forestry Department
FINDECO	Financial Development Corporation
FPRD	Forest Products Research Department
GRZ	Government of the Republic of Zambia
IDZ	Intensive Development Zones
INDECO	Industrial Development Corporation Ltd.
IRDP	Integrated Rural Development Programme
JICA	Japan International Cooperation Agency
LINTCO	Lint Company of Zambia
MAWD	Ministry of Agriculture and Water Development
MCOOP	Ministry of Co-operatives
MCI	Ministry of Commerce and Industry
MCL	Maamba Collieries Ltd.
MD	Meteorological Department
MINEX	Mineral Exploration Department, Exploration House, ZIMCO
MLNR	Ministry of Lands and Natural Resources
MOF	Ministry of Finance
MOM	Ministry of Mine
Mount Makulu	Agricultural Research Station, Lusaka
MTC	Ministry of Transport and Communication

NAMBOARD	National Agricultural Marketing Board
NATCO	National Tabacco Company
NCDP	National Commission for Development Planning
NCSR	National Council for Scientific Research
NCZ	Nitrogen Chemicals of Zambia Ltd.
NEC	National Energy Council
NIEC	National Import and Export Corporation Ltd.
NMB	National Marketing Board
NSE	Nakambala Sugar Estate
OFP	Operation Food Production (Zambia: 1980 - 1990)
PCMU	Provincial Cooperative Marketing Unions
PFO	Provincial Forest Offices
PIC	Prices and Income Commission
PTA	Preferential Trade Area for Eastern and Southern Africa
SAA	Senior Agricultural Assistant
SADCC	Southern African Development Co-ordination Committee
SIDO	Small Industries Development Organization
TAZARA	Tanzan Railway
TBZ	Tabacco Board of Zambia
UNIP	United National Independency Party
UNZA	University of Zambia
Zambia	Republic of Zambia
ZADB	Zambia Agricultural Development Bank
ZABS	Zambia Bureau of Standards
ZCCM	Zambia Consolidated Copper Mines Ltd.
ZCF	Zambia Cooperative Federation
ZESCO	Zambia Electricity Supply Corporation Ltd.
ZHPL, ZAMHORT	Zambia Holiticultural Product Ltd. (Zam Hort)
ZIMCO	Zambia Industrial and Mining Corporation Ltd.
ZIT	Zambia Institute of Technology
ZNEL	Zambia National Energy Ltd.
ZR	Zambia Railways
ZSC	Zambia Sugar Company Ltd.

Units Conversion Factors

Acre, A	1.0 Acre = 4,047 m^2
ata	Atmospheric Pressure in Absolute
atg	Atmospheric Pressure in Gauge
BBL	Barrel, 1.0 BBL = 42.0 US Gallon = 34.97 Imperial Gallons
BSCF, BCF	Billion SCF
BSCFD	Billion SCF per Day
BTU	British Thermal Unit, 1.0 BTU = 0.252 kcal
Bushel	1.0 Bushel = 34.25 Liters
DWT	Deat Weight Ton
EL	Elevation Level
GW	Giga Watt, Billion Watt
Ha	Hectare, 1.0 ha = 10,000 m^2 = 2,471 Acres (A)
HHV	High Heating Value
Gallon	1.0 US Gallon = 0.003785 m^3 1.0 Imperial Gallon = 0.004546 m^3
kVA	Kilovolt-Ampere
kW	Kilowatt
kWh	Kilowatt-Hour = 3.413 BTU
LHV	Low Heating Value
Mills	US Cents 0.1/kWh
MW	Megawatt, Million Watt
MMBTU	Million BTU
MMSCF	Million SCF
MMSCFD	Million SCF per Day
MSCF	Thousand SCF
MSL	Mean Sea Level
Nm^3	Normal Cubic Meter measured at 0°C and 1.0 ata
psi	Pound per Square Inch 1.0 psi = 0.07031 kg/cm^2
SCF, CF	Standard Cubic Feet measured at 60°F and 14.7 lb/in^2 1.0 SCF = 0.0283 Nm^3
SCFD, CFD	Standard Cubic Feet per Day
STB	Standard Tankage Barrel 1.0 STB = 0.159 Litre (60°F)

TSCF, TCF	Trillion SCF	
TPH	Ton per Hour	
TPD	Ton per Day	
TPT	Ton per Ton	
TPY	Ton per Year	
Ton, ton	Metric Ton	
K, K_2O	1.0% K	= 1.2046% K_2O
	1.0% K_2O	= 0.8302% K
P, P_2O_5, BPL	1.0% P	= 2.2914% P_2O_5
		= 5.0073% BPL
	1.0% P_2O_5	= 0.4364% P
		= 2.1853% BPL
	1.0% BPL	= 0.1997% P
		= 0.4576% P_2O_5
Fe, FeO, Fe_3O_4	1.0% Fe	= 1.2865% FeO
Fe_2O_3		= 1.3820% Fe_3O_4
		= 1.4297% Fe_2O_3
Ca, CaO, $CaCO_3$	1.0% Ca	= 1.3992% CaO
	1.0% CaO	= 1.7848% $CaCO_3$
Mg, MgO, $MgCO_3$	1.0% Mg	= 1.6582% MgO
	1.0% MgO	= 2.0916% $MgCO_3$
S, SO_2, SO_3	1.0% S	= 1.9980% SO_2
		= 2.4970% SO_3
		= 2.9960% SO_4

Fertilizer

Av-P_2O_5	Available Phosphate, Neutral Ammonium Citrate Soluble P_2O_5
AN	Ammonium Nitrate Fertilizer, (34.5-0-0)
A-N	Ammoniacal Nitrogen
APP	Ammonium Poly-Phosphates, (11-55-0)
AS	Ammonium Sulfate Fertilizer, (21.2-0-0)
BPL	Bone Phosphate of Lime in Terms of $Ca_3(PO_4)_2$, BPL/P_2O_5 = 2.1853
CAN	Calcium Ammonium Nitrate Fertilizer, (26-0-0)
CCN	Calcium Cyanamida Fertilizer, (21-0-0)
CF	Compound Fertilizer, (N-P_2O_5-K_2O)

CN	Calcium Nitrate Fertilizer, (16-0-0)
C-P_2O_5	Citric Acid Soluble P_2O_5
C-MgO	Citric Acid Soluble MgO
CX	Complex Fertilizer, (N-P_2O_5-K_2O)
DAP	Diammonium Phosphate Fertilizer, (18.2-46.4-0)
FMP	Fused Magnesium Phosphate, (0-20.11-0), P_2O_5 in Terms of C-P_2O_5
F-P_2O_5	Formic Acid Soluble P_2O_5
N	Nitrogen Nutrient Expressed in Terms of N
N-N	Nitrate Nitrogen
NP	Nitric Phosphate, (28-14-0) or (23-23-0)
NP/NPK	Compound Fertilizer or Complex Fertilizer, (N-P_2O_5-K_2O)
MAP	Monoammonium Phosphate Fertilizer, (16.2-48.4-0)
MOP	Muriate of Potash, Potassium Chloride Fertilizer, (0-0-60)
PAPR	Partially Acidulated Phosphate Rock
SOP	Sulfate of Potash, Potassium Sulfate Fertilizer, (0-0-50)
SSP	Single Super Phosphate Fertilizer, (0-17.20-0), P_2O_5 in terms of Av-P_2O_5
TCP	Tri-Calcium Phosphate; $CaO_3(PO_4)_2$, (0-45.76-0)
TPL	Tri-Phosphate of Lime; $CaO_3(PO_4)_2$, (0-45.76-0)
T-K_2O	Total Potash, Nitric Acid Soluble K_2O
T-N	Total Nitrogen
T-P_2O_5	Total Phosphate, Nitric Acid Soluble P_2O_5
TSP	Triple Superphosphate Fertilizer, (0-46.4-0)
U-N	Urea Nitrogen
Urea	Urea Fertilizer, (46.4-0-0)
W-N	Water Soluble N
W-K_2O	Hot Water Soluble K_2O
W-P_2O_5	Water Soluble P_2O_5

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SUMMARY, CONCLUSION AND RECOMMENDATIONS

1. OUTLINE OF THE PROJECT

1.1 Project Background

In accordance with the request of the Government of the Republic of Zambia (GRZ), Japan International Cooperation Agency (JICA) has undertaken a Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia.

The objectives of the study are to examine the marketing and technical aspects as well as financial and economic analysis on the proposed projects to produce two alternative products: fused magnesium phosphate (FMP) or single super phosphate (SSP) in Zambia by using domestic phosphate concentrate which will be mined and concentrated at Chilembwe, Zambia. At present all phosphate fertilizer is imported and the reserves of Chilembwe had been confirmed to serve 10,554 TPY of P_2O_5 supply over 14 years of project life as import substitute of phosphate fertilizer in Zambia.

The economy of Zambia has been heavily dependent on copper mines, but since the sharp decline of the copper export price in 1974, Zambia's development strategy has given high priority to agriculture and rural development, especially to achieve self-sufficiency in major foodstuffs. Fertilizer is the most important input for the agricultural development in Zambia. The availability of surplus hydroelectric power and sulfuric acid at low cost in Zambia are advantageous for the production of two product alternatives.

The JICA study team made a detailed study under the assistance and guidance of INDECO as coordinating body and counterpart agency for the study and took representative mineral samples of Chilembwe phosphate ore and Mkushi serpentine in Zambia during November and December 1986, and made evaluation tests for the concentration of phosphate and the production of two product alternatives.

The experimental works and studies have verified the technical feasibility of the proposed projects to produce standard quality products by conventional process technologies.

1.2 Project Facilities

Based on the experimental works and detailed analysis on the proposed projects, the conceptual design of the project facilities have been developed as outlined below:

Basic Features of Proposed Projects

Proposed Project	Location, Site Area, m^2	Product and Specification	Rated Capacity TPY	Permanent Employment	Capital Investment US$, MM -1991
- Phosphate Mining and Concentrate, I	Chilembwe 779,000	Phosphate Concentrate (P_2O_5 30.00%, CaO 41.11%)	35,181	117	14.6
- Fused Magnesium Phosphate, II	Kafue 27,000	Fused Magnesium Phosphate, Bags (0-20.11-0)	50,400	83	21.5
or					
- Single Super Phosphate, III	Kafue 20,800	Single Super Phosphate, Bulk (0-17.20-0)	57,205	74	19.8

The proposed project calls for the production of 50,400 TPY of fused magnesium phosphate or 57,205 TPY of single super phosphate using 35,181 TPY of Chilembwe phosphate concentrate, starting commercial production in 1991 for the 15 years of project life.

The processes applied are open pit mining, flotation and filtration for the phosphate mining and concentrate project, electric furnace reaction to process Chilembwe phosphate concentrate and Mkushi serpentine mixture to produce fused magnesium phosphate, and acidulation and curing of Chilembwe phosphate concentrate by sulfuric acid which will be supplied from NCZ, Kafue for the production of single super phosphate fertilizer.

It is assumed that new state-owned organizations would be established for the promotion of the projects as a national project under MINEX for the phosphate mining and concentrate project and under INDECO for the phosphate fertilizer project, and simultaneously seek the technical assistance of an international engineering consultant for the execution of the projects.

The phosphate mining and concentrate project will be located in Chilembwe in view of the access to the reserves and the phosphate fertilizer projects will be located in Kafue in view of the physical distribution of raw materials and product in Zambia. Kafue is selected as the optimum location among four pre-selected sites: Kafue, Kabwe, Ndola and Kitwe.

The construction schedule is projected that the contract will be awarded under a lump-sum and full-turn-key type contract in July, 1989 for the mechanical completion in March, 1991 and the commencement of commercial production in July, 1991.

The proposed phosphate fertilizer products would be sold in the domestic market through NCZ and NAMBOARD. The rated capacity of phosphate fertilizer will serve only a half to a third of the national requirements of Zambia due to the limited reserves of Chilembwe phosphate ores.

The annual sales and product selling price are projected as follows:

Product Sales Projection

Year	Fused Magnesium Phosphate			Single Super Phosphate		
	Product Sales TPY	Unit Price US$/Ton-Bags - 1991	Annual Sales US$,MM - 1991	Product Sales TPY	Unit Price US$/Ton-Bulk - 1991	Annual Sales US$,MM - 1991
1991						
(1/2 year)	15,120	180.0	2.72	17,162	150.0	2.57
2	37,800	180.0	6.80	42,904	150.0	6.44
3	45,360	180.0	8.16	51,485	150.0	7.72
4	50,400	180.0	9.07	57,205	150.0	8.58
5	50,400	180.0	9.07	57,205	150.0	8.58
...	...	...	...	...	...	...
2005						
(1/2 year)	30,240	180.0	5.44	34,323	150.0	5.15
Project Life Total/ Average	735,840	180.0	132.45	835,193	150.0	125.28

1.3 Financial Analysis and Economic Evaluation

Although the proposed projects are found to be technically feasible, the financial analysis shows that the projects are not financially viable in terms of return on investment as well as cash flow under assumed long term loan interest rates of either 4%/year or 12%/year. Financial internal return on investments are found to be all negative. The financial analysis is summarized as follows:

Project Financial Analysis Summary

Long Term Interest Rate	FIRROI, DCF, After Tax, %		Project Life Average Debt Service Ratio		Transfer Price of Phosphate Concentrate	
	4.0%	12.0%	4.0%	12.0%	4.0% $/Ton	12.0% $/Ton
Individual Projects						
- Phosphate Mining and Concentrate, I	(-)4.29	(-)4.27	0.35	(-)2.76	(130.0)	(130.0)
- Fused Magnesium Phosphate, II	(-)10.11	(-)10.06	(-)1.27	(-)3.50	(130.0)	(130.0)
- Single Super Phosphate, III	(-)3.53	(-)3.52	0.64	(-)2.18	(130.0)	(130.0)
Integrated Projects						
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	(-)8.04	(-)8.00	(-)0.51	(-)3.12	120.3	120.3
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	(-)3.85	(-)3.84	0.63	(-)2.27	131.3	131.3

The two alternative projects are financially not viable; it is noted, however, that the return is a little higher for the production of single super phosphate than fused magnesium phosphate. The sensitivity analysis reveals that the product price is the most sensitive and to realize financially viable returns, the product price should be more than 60% higher than the projected product price as import substitute pricing, which is considered unlikely in view of present and near future international phosphate fertilizer markets which are suffered from

excessive supply capacity as well as the expansion projects in developing countries.

The economic analysis shows that the return on investment for the proposed projects are also negative. The net foreign exchange savings gained from import substitution of phosphate fertilizer are fairly large for the single super phosphate project but are marginal for the fused magnesium phosphate project. However it is anticipated that the savings for the fused magnesium phosphate project might be improved if the higher effectiveness of fused magnesium phosphate fertilizer is confirmed by the agronomical tests in Zambia. The economic benefit is not so attractive for the economy of the Republic of Zambia under the present and assumed near future conditions of phosphate fertilizer industries in the world.

2. SUMMARY OF THE STUDY RESULTS

2.1 Market Aspects

2.1.1 Agriculture and Fertilizer Consumption, Supply and Distribution in Zambia

(1) Consumption of Fertilizer in Zambia

The consumption of fertilizer in Zambia had increased year by year until 1977 as shown in Table 2-1-1. However, after that, the consumption level fluctuated year to year, and the highest consumption level recorded after 1980 was 218,800 tons (in nutrient equivalents, 57,800 tons for N, 21,700 tons for P_2O_5 and 8,000 tons for K_2O respectively).

One of the characteristics of fertilizer consumption pattern in Zambia is that most fertilizer is consumed as compound fertilizer. Most fertilizer has been used on maize. Large and medium-scale commercial farmers apply fertilizer on maize almost without exception. In the case of small-scale commercial farmers, they apply fertilizer on maize in general, but sometimes do not apply it because of lack of money or credit to buy fertilizer. However, subsistence farmers do not apply fertilizer at all because of lack of purchasing power, although they desire to apply fertilizer since they know the effectiveness of fertilizer for improving yields, having seen what large-scale farmers achieve.

(2) Fertilizer Supply and Distribution in Zambia

The total balance of fertilizer in Zambia in 1983 through 1986 is shown in Table 2-1-2. Most supply has been imported. NCZ is the sole producer of fertilizer in Zambia, and has production facilities for ammonia, ammonium nitrate, ammonium sulphate and compound fertilizer.

Fertilizer distribution has been monopolized by NAMBOARD; except for the raw material fertilizers imported by the NCZ, all the fertilizers have been imported by the NAMBOARD, and all the fertilizers produced by the NCZ have been distributed by the NAMBOARD. (Figure 2-1-1).

In 1986, the government decided to liberalize fertilizer distribution by abolishing the monopoly of NAMBOARD.

However, because of insufficient provision with respect to funds and facilities (especially transportation facilities) together with existence of subsidies (or official prices), liberalization was not materialized this year and the NAMBOARD handled the distribution as in the past.

(3) Fertilizer Price and Subsidy on Fertilizer

The price of fertilizer has been fixed at two levels by the government, namely, the sales price of NCZ to NAMBOARD and the price at outlets. The sales price of NCZ to NAMBOARD has been set lower than the production cost of NCZ in recent years, and the difference is to be compensated by the government. This difference is called the producer subsidy.

The sales prices at all outlets are the same regardless of the location of the outlets. The difference between the set price and the cost delivered to the outlet, which varies depending on the distance from the origin, is called transportation subsidy.

Table 2-1-3 compares the landed cost of imported fertilizer by NAMBOARD, official purchase price from NCZ, and official sales price by NAMBOARD.

(4) Physical distribution of fertilizer

The domestically produced fertilizer is purchased by NAMBOARD at the factory from NCZ, transported to the major depots either by road or rail, and further to outlets.

Imported fertilizers are unloaded mainly at Dar-es-Salaam in Tanzania, bagged there and transported directly to main depots by rail.

2.1.2 Marketability of FMP and SSP in Zambia

(1) Marketability of FMP

1) Marketability of FMP as a phosphate fertilizer

All the phosphate fertilizer used in Zambia contains water-soluble phosphate, while the FMP contains citric-soluble phosphate only. So far, no well organized field experiments have been conducted in Zambia regarding the effectiveness of citric-soluble phosphate on crop yield. According to a limited number of FMP applications in Zambia, the effectiveness of FMP is understood to be equal to that of water-soluble phosphate fertilizers.

One percent of citric-soluble phosphate is equivalent to that of water-soluble phosphate in its effectiveness in general, in the acidic soil area widely distributed in Zambia. The area of Zambia where the effectiveness of FMP is expected covers most except for limited areas as shown in Figure 2-1-2.

According to the prevailing fertilizer application practice, the phosphate fertilizer is applied as basal dressing, and in compound fertilizer. Therefore, the introduction of FMP will not be easy in Zambian market without modifying the present fertilizer application practice. At present, there is an opinion among the leaders in agricultural sector to promote the use of domestically produced fertilizer, modifying the fertilizer application practice in view of financial difficulty of the country. With such support for the introduction of FMP as a domestically produced fertilizer, the marketability of FMP may be expected despite the above described difficulties in its introduction.

2) Marketability of FMP based on the additional effects by the accessory contents

In the case of FMP, the effect of the accessory contents in addition to the phosphate fertilizer may be expected due to MgO, CaO and silicic acid in it. One is the effect to supply the soil with these nutrients, and another is the effect on the soil acidity. The former effect is not taken into account in examining the marketability of FMP in this study, since no experiment has been undertaken on this point in Zambia.

The CaO and MgO contained in the FMP are effective to amend soil acidity, as stated in the foregoing section. However, in order to expect such effect, a large volume of FMP must be applied. The present recommended dosage of phosphate fertilizer is 20 - 40 kg P_2O_5/ha at most in Zambia, and it is hard to expect the significant acidity ammendment effect from that level of FMP application even with several years of continued application.

Thus, it may be concluded that the effect of contained CaO and MgO as acidity amendment material is hard to evaluate in addition to that of contained phosphate, without confirming the effectiveness through field tests on Zambian soil.

(2) Marketability of SSP

The phosphate contained in SSP is mostly water-soluble, and the effectiveness of the contained phosphate is equivalent to that of other phosphate fertilizers now used in Zambia. Therefore, marketability of SSP in view of effectiveness is not in question at all.

Further, sulphur application is effective in the case of Zambian soil, and therefore, contained sulphur is valuable in addition to the above.

2.1.3 Projection of Sales Prices of FMP/SSP

(1) Condition and Assumptions of Sales Price Projection

The distribution and market price of fertilizer is controlled by the government. The import and distribution are monopolized by the state company, NAMBOARD, and the market price is set by the government. The basic policy of the government is to gradually reduce governmental control. An effort to abolish the distribution monopoly was made in 1986 as the first step of this liberalization. In this price projection, the market price is assumed to be formulated on the basis of competition among the products from various sources as well as suppliers, with decontrol in setting the price.

(2) Projection of Sales Price of FMP/SSP

In the case of introduction of FMP/SSP to a market where the use of compound fertilizer is established, there are some non-price disadvantages. Namely, the introduction of FMP/SSP will increase the number of total bags of fertilizer to be used and moreover, pre-mix of FMP with other fertilizers is necessary in the case of FMP, thereby increasing inconvenience. Thus, the total cost of FMP and other fertilizer, or compound fertilizer using SSP, should be less than that of the present application pattern if use of FMP/SSP is to be accepted.

However, if the farmers change their practice of using a combination of straight fertilizer by the time of introduction of FMP/SSP, as a result of liberalization of fertilizer distribution, then the farmers' attitude toward the selection of new fertilizer is a little different from the case examined in the foregoing section. In such case, whether the farmers will use the FMP/CX-SSP or not depends on the cost to them of using FMP/CX-SSP in comparison with that of phosphate fertilizer. The price of FMP should be equivalent to or less than that of the fertilizer now in use, in terms of 1% phosphate content.

On the basis of the foregoing examination, the sales price of FMP/SSP is projected as follows:

Projected Potential Sales Prices of FMP/SSP

	Ex-factory Price (US$/ton)
FMP	US$110/ton±20%
SSP	US$97/ton*/

Note: */ Expected maximum price

(3) Policy Option on Fertilizer Distribution, and its Influences on Sales Prices

In the foregoing section, the price of FMP/SSP was projected on the assumption that the distribution of fertilizer will be liberalized. However, it will take time before a number of distributors will become established in the business, in view of present situation of distribution. At the same time, the liberalization of price formulation is also doubtful since the liberalization of prices must be done together with that of other goods. The possibility to realize the free import is closely related to the policy option of how to deal with domestic production, namely the operation of NCZ. In the following sections, the influence on the projected prices of FMP/SSP of such policy options relating to the fertilizer distribution is examined.

1) The case in which the price increase rate will be controlled at the same rate of general price increase (Scenario 1)

This scenario assumes that the prices of all the fertilizers are increased by 3.0% p.a. (the same increase rate as that of general price) from the official price in 1986. In this case, the prices in mid-1991 will be lower than the imported cost of fertilizers and it implies that the fertilizers are subsidized at that time.

Assuming the introduction of FMP to such a market, the projected salable price of FMP will be as low as US$80/ton (ZK640/ton). This is because the cost of fertilizers to be replaced by the FMP is kept at a lower level than import costs by the official prices.

The producer of the FMP will be entitled to receive a subsidy, in this case. The rate may vary depending on the policy decision with respect to the extent of protection of domestic producers. The projected sales price of FMP will be about US$110/ton (ZK880/ton), assuming the rate 25%.

The SSP cannot be priced with this scenario again.

2) The case in which the operation of NCZ is assumed as the basis of policy option (Scenario 2)

The shortage of foreign exchange in Zambia might remain unchanged in the future if the international copper market stays soft. Since the operation of NCZ results in foreign exchange saving through utilization of domestic resources of nitrogen, there is possibility for the distribution of fertilizer, which competes with that of NCZ, to be restricted to protect the operation of NCZ.

If such is the case, the liberalization will be limited to some extent. However, at what cost level the price is to be set varies depending on such factors as general price change, extent of foreign exchange shortage, direction of agricultural policy, availability of financial funds for fertilizer subsidies, etc.

The lowest case among them will be the one in which the fertilizer price is increased at the rate of general price increase, as shown in Scenario 1, and the highest case is the one in which the price is set to cover the cost of domestic production of NCZ for domestic compound fertilizers and the cost of import for imported straight fertilizers. There are various alternatives of price level between the two extreme cases depending on the policy option.

The sales price of FMP was projected with the assumption that the formulation cost of compound fertilizer accounts for 15-25% of total production cost. Since the FMP replaces a part of compound fertilizer now used, the higher the price of compound fertilizer, the higher the possible sales price of FMP, with the highest case being US$178/ton (ZK1,424/ton).

Assuming that NCZ continues to operate, the possible sales price of SSP as a raw material of compound fertilizer for the producer of compound fertilizer (NCZ) will be equivalent to, or less than, that of other phosphate fertilizer in terms of 1% phosphate content. The highest price under such circumstance is US$142/ton (ZK1,139/ton).

2.1.4 Projected Market Quantity Volume of FMP/SSP in Zambia

Most fertilizer in Zambia is consumed for maize. In this context, the major factor affecting the demand for fertilizer is change in the cultivation area of maize in commercial farm sector. In the long term, the maize cultivation area increases in accordance with increase in urban population, which results in the increase in maize demand and gives an incentive for maize production. However, the maize cultivation area does not necessarily increase directly in response to increase in the urban population and therefore demand for maize.

Therefore, in the projection of phosphate fertilizer demand, the maize cultivation area is firstly projected, and then, multiplying the 112 N kg/ha, 40 P_2O_5 kg/ha, and 20 K_2O kg/ha of present recommended dosages by the above-forecast cultivated areas, the potential demand was projected. Further, using the realization rate of the potential demand in the past, by province, the demand for fertilizer was projected by province.

The result of projections for the phosphate fertilizer is given in Table 2-1-4.

What extent of demand for phosphate fertilizer will be materialized as the demand for FMP, depends on the sales promotion measures to be taken when FMP is introduced, the level of sales price as well as the support given by the leaders in the agricultural sector. In this projection, these factors are assumed to be fulfilled sufficiently.

SSP is applicable for all areas where phosphate demand exists, since it contains water-soluble phosphate and is sold as compound fertilizer.

Thus, the market quantity may be decided by the potential amount that can be supplied instead of market size. The market volume of FMP, assuming that the sales is confined to the acidic soil area, and that of SSP with assumption that 30% of requirement of phosphate is fulfilled by the SSP, are given in Tables 2-1-5 and 2-1-6.

2.2 Raw Material Suppliability

2.2.1 Fertilizer Production Plant

In Zambia, there is one fertilizer manufacturing plant of Nitrogen Chemicals of Zambia Ltd. (NCZ) which is located in the Industrial Estate of Kafue, approximately 44 km south from Lusaka and has two trains of ammonia production facility using Maamba coal as raw material with annual combined capacity of 96,000 TPY of ammonia. Product ammonia is captively consumed for the production of nitric acid, ammonium nitrate, ammonium sulfate and compound fertilizer granulation. The capacity utilization has been less than a half and the plant is now under rehabilitation programs.

After the completion of the rehabilitation works in 1988, the overall inputs and outputs of the NCZ is projected as follows:

Production Balance Projection at NCZ — Unit: 1,000 TPY

Inputs		Intermediates		Salable Products	
Coal, Maamba	191.7	Ammonia	96	Nitric Acid	7.7
Pyrite, Nampundwe	40	Nitric Acid	120	Sulfuric Acid	10
Lime, CSSL	8.5	Sulfuric Acid	60	Ammonium Nitrate	
DAP, Import	27.5	Ammonium Nitrate	140	- Fertilizer	85
TSP, Import	23.7	Ammonium Sulfate	50	- Explosives	24
SOP, Import	9.6	Compound Fertilizer	142.32	Compound Fertilizer	142.32
MOP, Import	3.8	Methanol	1.65	Methanol	1.65
Conditioner, Import	1.5	Carbon Dioxide	1	Carbon Dioxid	1
Raw Water, Kafue River	21,600 TPD				
Electricity, ZESCO	46 MW				

All the fertilizer product from NCZ is sold to NAMBOARD, parastatal agency under the Ministry of Cooperatives for domestic marketing and physical distribution in Zambia. The domestic transport of the products are in bags and through railways and/or road vehicles to the NAMBOARD's depots at 15 locations in Zambia. NAMBOARD receives subsidies for fertilizer price differential and fertilizer handling cost and has monopoly role over the procurement of fertilizer both from the domestic plant and imports (commercial and bilateral aid). Final marketing and distribution of fertilizer is undertaken by Provincial Cooperative Marketing Units (CMU) under the Ministry of Cooperatives, which have 18 fertilizer depots throughout Zambia.

2.2.2 Fertilizer Control and Regulation

In Zambia, regulation and control of fertilizer are as stipulated in the Agriculture (Fertilizers and Feed) Act - Chapter 351 of the Law of Zambia which defines the fertilizer, method of analysis and maximum variation allowance for nutrients as well as the quantity and quality control of fertilizer in Zambia.

The main features of fertilizer regulation in Zambia are: fertilizer is quantified in terms of elements not only in N but also P and K instead of oxides, water soluble phosphate is recognized as legally effective phosphate fertilizer, and nitrate nitrogen and sulfate type potash are given high importance in the legislation. However, among industry and commerce the international practices are widely accepted in Zambia.

2.2.3 Supply of Raw Materials

For the production of proposed phosphate fertilizer products, several raw materials are required and their suppliability in Zambia are studied. The combination of raw material and product studied is summarized as follows:

Product Alternatives and Raw Materials

Product Alternatives	Raw Materials
Fused Magnesium Phosphate	Phosphate Concentrate and Serpentine
Single Super Phosphate	Phosphate Concentrate and Sulfuric Acid
Triple Super Phosphate	Phosphate Concentrate and Sulfuric Acid
Diammonium Phosphate	Phosphate Concentrate, Sulfuric Acid and Ammonia
Nitric Phosphate	Phosphate Concentrate, Nitric Acid, Ammonia and Carbon Dioxide

(1) Phosphate

MINEX concluded that the development of Chilembwe phosphate ore is the most promising in Zambia, and a detailed study was undertaken in 1984/85. The study results are presented in "A Pre-Feasibility Study for the Phosphate Development Project, the Republic of Zambia, 1985, Japan International Cooperation Agency".

The study demonstrates that the minable phosphate reserve in Chilembwe is 1.55 million tons of 11.5% P_2O_5 quality and 40,000 TPY-wet of phosphate concentrate with 30.00% P_2O_5 quality (dry) will be recovered annually by the flotation process. The reserve is small and limited, and will be mined out in 15 years of project life.

(2) Serpentine

MINEX, ZIMCO made a study on the serpentine reserve at Muloba, Mkushi in 1986. The study results are documented in "Occasional Report on the Muloba Serpentine, Mkushi District, Central Province, Zambia, MINEX, ZIMCO, September, 1986". The reserve is located at 55 km north-east of Kapiri Mposhi along Great North Road and TAZARA railways system.

According to the report, the major minerals of the reserves are antigorite ($3\ MgO \cdot 2SiO_2 \cdot 2H_2O$) and calcite. Tourmaline, chrysotile and serpophite are associated. The crystalline size is averaged 0.2 mm in diameter and specific gravity of the minerals measured as 2.5. The reserve is high quality in MgO and SiO_2, and large enough for supporting the project for more than 32 years of operation.

It is assumed that MINEX, ZIMCO will implement the serpentine mining project and supply crushed serpentine to the fused magnesium phosphate project upon the approval of the project.

(3) Sulfuric Acid and Others

For the production of single super phosphate, approximately 20,000 Tons of sulfuric acid is required for the proposed project, annually. Sulfuric acid is produced at NCZ, Kafue and ZCCM, Chambishi and Nkana, both near Kitwe, Zambia.

NCZ has a sulfuric acid plant using pyrite from Nampundwe Mines of ZCCM, approximately 50 km west of Lusaka. Annual design capacity of the plant is 60,000 TPY and was completed in 1983. The supply of pyrite is considered adequate but the capacity utilization in 1986 is less than a half because of the low operating rate of the down-stream ammonium sulfate plant.

Sulfuric acid balance at NCZ upon the completion of rehabilitation works in 1988 is estimated as follows:

Sulfuric Acid Balance at NCZ, 1989

Design Capacity	60,000 TPY
Annual Production	60,000
Consumption	
- NCZ's Captive Uses	50,075
- Ammonium Sulfate (50,000 TPY)	(39,075)
- Direct Use for Compound Fertilizer (142,300 TPY)	(11,000)
Outside Sales	
- Alum Production in Kafue	7,000
Surplus	2,925

Therefore, in principle, under the assumed conditions above, sulfuric acid supply is not adequate for the proposed single super phosphate project in Zambia. However, in practice, considering the objectives of ammonium sulfate production at NCZ is to supply sulfur nutrients in compound fertilizer for applying sulfur to sulfur deficit soil in Zambia, then the diverting sulfuric acid from present ammonium sulfate production to single super phosphate production will create a same result in sulfur balance in Zambian agriculture, because the new product of single super phosphate is containing sulfur nutrient and destined to the farm soil in Zambia.

From the discussion above, it may be reasonable to assume that NCZ will agree to divert a portion of sulfuric acid from the present production of ammonium sulfate to the proposed single super phosphate production according to the pricing of sulfuric acid and other national economic benefits, if manifested.

2.3 Technical Aspects

2.3.1 Production Tests

(1) Phosphate Concentrate

The representative phosphate ore was taken at Chilembwe on November 28, 1986 in consultation with MINEX and a 220 kg weight sample was taken back to Japan for the detailed analysis and for preparation of phosphate concentrate, which was further used for the production tests of fused magnesium phosphate and single super phosphate.

The minerals in the phosphate concentrate from Chilembwe ore are identified by X-ray diffraction and chemical analysis that the major minerals are fluorapatite [$3Ca_3(PO_4)_2 \cdot CaF_2$] and hydroxyapatite [$3Ca_3(PO_4)_2 \cdot Ca(OH)_2$], and quartz ($SiO_2$) and hornblende ($2CaO \cdot 5MgO \cdot 8SiO_2 \cdot H_2O$) are associated as minor contaminants.

The analysis of recovered phosphate concentrate is 33.69% P_2O_5 and 46.18% CaO on a dry basis and production tests were carried out using the phosphate concentrate, but the conceptual design of phosphate fertilizer plants were formulated assuming that phosphate with 30.00% P_2O_5 and 41.11% CaO analysis will be supplied from Chilembwe as an average during the project life because of allowance of design basis of phosphate mining and concentrate project.

(2) Fused Magnesium Phosphate

Fused magnesium phosphate is produced in an electric furnace by melting and reacting of phosphate concentrate and serpentine. The production tests were carried out by using batch-wise experimental electric furnace with 7 kg batch sample which is melted at 1,300°C for 50 minutes and the molten reaction product is quenched in water bath to obtain glassy fused magnesium phosphate product. The product quality is high in citric acid solubility of phosphate. No difference in quality is observed between Zambian and Japanese products in chemical analysis and X-ray diffraction analysis.

(3) Single Super Phosphate

Single super phosphate is a reaction product between phosphate concentrate and sulfuric acid, and its production reaction is expressed in the case of fluorapatite as follows:

$$\underset{\text{(Fluorapatite)}}{3Ca_3(PO_4)_2 \cdot CaF_2} + 7H_2SO_4 + 3H_2O$$

$$= \underset{\text{(Single Super Phosphate)}}{3Ca(H_2PO_4)_2 \cdot H_2O} + 7CaSO_4 + 2HF$$

Production tests of single super phosphate were undertaken by using phosphate concentrate recovered from Chilembwe phosphate ore in comparison with Florida phosphate concentrate, the USA because Florida phosphate is widely used for the commercial production of phosphate fertilizer throughout the world.

The results indicate that standard grade single super phosphate is produced from phosphate concentrate recovered from Chilembwe phosphate ore in Zambia.

It is noted that the reactivity of phosphate from Chilembwe with sulfuric acid is lower than that of Florida and takes longer den residence time and higher temperature for complete reaction and solidification of the reaction mass.

2.3.2 Project Site Selection and Utility Supply

During the course of the field work from November to December, 1986 in Zambia, four alternative sites for the proposed phosphate fertilizer plant project were pre-selected in consultation with INDECO. Major factors taken into consideration were the raw materials and product transport, utilities supply of industrial water and electricity as well as the infrastructure development situation and technical level of personnel available in the region at present and in near future.

The pre-selected candidate sites in Zambia are as follows:

Township of Alternative Sites		Locality
(1)	Kafue	Southwest of NCZ
(2)	Kabwe	Chimanimani Village
(3)	Ndola	Industrial Area
(4)	Kitwe	Industrial Area

The pre-selected four project sites have different features, but Kafue, Ndola and Kitwe are almost identical in utility, infrastructure and technical level while Kabwe is disadvantageous in water supply at present.

The most important factor for the selection of the site is the transport cost for raw material and product. For the production of fused magnesium phosphate, approximately 40,000 TPY of phosphate concentrate from Chilembwe, 20,000 TPY of serpentine from Mkushi to the project site and 50,000 TPY of product should be transported. For the production of single super phosphate, approximately 40,000 TPY of phosphate concentrate from Chilembwe, 20,000 TPY of sulfuric acid from NCZ, Kafue to the project site and 57,000 TPY of product to NCZ, Kafue should be transported.

Therefore, the proposed phosphate fertilizer project should be located in Kafue as the optimal site in view of raw material and product transport. Phosphate concentrate should be transported by road from Chilembwe. Kafue is located nearest to Chilembwe and also nearest to the center of the phosphate fertilizer market in Zambia. The utility supply, infrastructure and technical aspects are considered almost identical among Kafue, Ndola and Kitwe except in Kabwe where raw water supply is tight at present. Kafue is also advantageous in view of the well established operations of NCZ which will be able to assist and collaborate with the phosphate fertilizer project in utility supply, maintenance and operation as well as project management during implementation and operation stages.

2.3.3 Conceptual Design of the Projects

In this feasibility study, there are three projects to be studied. One up-stream project: the phosphate mining and concentrate project located in Chilembwe, and two alternative down-stream projects: the fused magnesium phosphate project or the single super phosphate project, both located in Kafue. There is another small scale project of up-stream: the mining of serpentine project located in Mkushi, but in view of smaller investment cost required the project is assumed as an independent operation of MINEX to deliver the crushed serpentine to the fused magnesium phosphate project in Kafue at cost.

(1) Phosphate Mining and Concentrate Project

The conceptual design and feasibility study of the up-stream project were completed in 1985. The project will be located in Chilembwe to mine and process 332,400 TPY of phosphate ore to produce 35,181 TPY--dry phosphate concentrate: 30.00% P_2O_5 and 41.11% CaO. The phosphate concentrate is coming out as wet with 12% free moisture which will be transported for 541 km by road under a long term haulage contract to Kafue.

(2) Fused Magnesium Phosphate Project

The project will be located in Kafue and consume 35,181 TPY-dry of phosphate concentrate from Chilembwe as well as 19,103 TPY-dry serpentine from Mkushi to produce 50,400 TPY of fused magnesium phosphate as final product.

Specification of the product is C-P_2O_5 20.11%, C-MaO 14.05% and S-SiO_2 26.16%, and citric acid solubility of phosphate is over 99% in the product.

(3) Single Super Phosphate Project

The project will be located in Kafue and consume 35,181 TPY-dry of phosphate concentrate from Chilembwe as well as 19,850 TPY of sulfuric acid from NCZ to produce 57,205 TPY of single super phosphate as final product.

Specification of the product is Av-P_2O_5 17.20%, W-P_2O_5 15.15% and available phosphate solubility is over 96% in the product.

(4) Integrated Projects

For the financial and economic analysis of the overall projects, an integrated project scheme should be formulated. There are two integrated projects: the phosphate mining and concentrate project (I) with the fused magnesium phosphate project (II) or the phosphate mining and concentrate project (I) with the single super phosphate project (III).

Complete conceptual design of five projects are prepared and financially analyzed: (I), (II), (III), (I + II) and (I + III).

2.4 Financial Analysis and Economic Evaluation

2.4.1 Financial Analysis

The financial viability of the project is analyzed in terms of financial internal rate of return on investment in constant price by the discounted cash flow method. In addition to the internal rate of return on investment, the cash flow during the project life is also carefully examined in terms of debt service ratio and annual requirements of short term loan.

Total financing required for the proposed projects are estimated using the prevailing prices in Zambia as well as the international market. The costs at the estimate date are escalated to the total financing required on the commencement date of the commercial production for the projects.

The capital cost estimates for the proposed projects are summarized as follows:

Financing Required and Financing Plan for the Projects, $,MM

Proposed Project	Financing Required			Financing Plan			Annual Sales
	Foreign Currency	Local Currency	Total	Equity	Long Term Loan	Total	
Individual Projects							
- Phosphate Mining and Concentrate, I	10.11	4.45	14.56	3.64	10.92	14.56	4.57
- Fused Magnesium Phosphate, II	16.66	4.86	21.52	5.38	16.14	21.52	9.07
- Single Super Phosphate, III	14.58	5.21	19.79	4.95	14.84	19.79	8.58
Integrated Projects							
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	26.77	9.31	36.08	9.02	27.06	36.08	9.07
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	24.69	9.67	34.36	8.59	25.77	34.36	8.58

Base Case: Interest Rate of Long Term Loan; 12.0%/year

Calculation results on the financial analysis, assuming two cases for long term interest rates: 4.0% and 12.0% for the proposed projects are summarized as follows:

Project Financial Analysis Summary

Long Term Interest Rate	FIRROI, DCF, After Tax, %		Project Life Avarage Debt Service Ratio		Transfer Price of Phosphate Concentrate	
	4.0%	12.0%	4.0%	12.0%	4.0% $/Ton	12.0% $/Ton
Individual Projects						
- Phosphate Mining and Concentrate, I	(-)4.29	(-)4.27	0.35	(-)2.76	(130.0)	(130.0)
- Fused Magnesium Phosphate, II	(-)10.11	(-)10.06	(-)1.27	(-)3.50	(130.0)	(130.0)
- Single Super Phosphate, III	(-)3.53	(-)3.52	0.64	(-)2.18	(130.0)	(130.0)
Integrated Projects						
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	(-)8.04	(-)8.00	(-)0.51	(-)3.12	120.3	120.3
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	(-)3.85	(-)3.84	0.63	(-)2.27	131.3	131.3

The project life average production costs are higher than the projected price as are cited below:

Project Life Average Production Cost, US$/Ton-1998

Project	Production Cost					Projected Price
	Variable/ Transport	Direct Fixed	Depreciation	Sales/ Interest	Total	
Individual Projects						
- Phosphate Mining and Concentrate, I	98.5	14.5	25.8	111.4	250.2	130.0 - Bulk
- Fused Magnesium Phosphate, II	162.3	9.9	25.8	128.1	326.1	180.0 - Bags
- Single Super Phosphate, III	127.4	7.7	19.9	79.2	234.2	150.0 - Bulk
Integrated Projects						
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	141.4	19.7	43.8	200.9	405.8	180.0 - Bags
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	108.0	16.3	35.8	141.2	301.3	150.0 - Bulk

Base Case: Interest Rate of Long Term Loan; 12.0%/year

The financial analysis for the proposed projects concludes that under the assumed conditions, the projects are not financially viable and give negative returns as well as negative net present values regardless of the interest rate of the long term loan within the range of 4.0% to 12.0% annually.

2.4.2 Economic Evaluation

The economic return is calculated in four steps: estimate of economic project cost, economic annual cost, economic benefits and computation of the return using converted economic data over the financial basic data of the proposed projects.

The economic evaluation are undertaken for the two integrated projects of up-stream and down-stream alternative projects in view of project features in Zambia.

Economic Internal Rate of Return on Investment, %

	EIRROI, DCF, %	
	Low Interest Rate Case, 4.0%/Year	Base Interest Rate Case, 12.0%/Year
Integrated Projects		
- Phosphate Mining and Concentrate, and Fused Magnesium Phosphate, I + II	(-) 10.07	(-) 10.07
- Phosphate Mining and Concentrate, and Single Super Phosphate, I + III	(-) 5.02	(-) 5.02

The net present value, if using cut-off rate of 12%, is negative, too.

The calculated net foreign exchange savings are $1.22 MM for fused magnesium phosphate and $23.63 MM for single super phosphate project as is summarized belows:

Project Life Foreign Exchange Savings, US$, MM/Year - Net Present Value - 1991

	Foreign Exchange for Import of Phosphate Fertilizer	Foreign Exchange Outlays from the Project		Net Foreign Exchange Saving
		Debt Service of Foreign Loan	Foreign Procurement	
Integrated Projects				
- Phosphate Mining and Concentrate Project, and Fused Magnesium Phosphate Project, I + II	87.46	28.49	57.75	1.22
- Phosphate Mining and Concentrate Project, and Single Super Phosphate Project, I + III	84.91	26.91	34.37	23.63

Notes:
- Interest rate for long term loan : 4.0%/Year
- Assumed import price of triple super phosphate : US$286/Ton at Kafue in 1991
- Escalation rate : 3.0%/Year
- Deflator : 3.0%/Year

Although the proposed project will create approximately 200 employment opportunities and will be contributable to technology transfer as well as the regional development in Zambia, the proposed and studied projects will not be contributable to the national economy in Zambia as a whole.

3. CONCLUSION AND RECOMMENDATIONS

3.1 Conclusion

The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia concludes that the proposed projects are technically feasible to recover phosphate concentrate (35,181 TPY, P_2O_5: 30.00%, CaO: 41.11%) in Chilembwe and to produce fused magnesium phosphate [50,400 TPY, (0-20.11-0), P_2O_5 in citric acid soluble] or single super phosphate [57,205 TPY, (0-17.20-0), P_2O_5 in ammonium citrate soluble] by using Chilembwe phosphate concentrate as major inputs in Kafue, Zambia.

However, the financial analysis illustrates that the proposed projects are not financially viable in terms of return on investment as well as cash flow during project life assuming the long term loan interest rates of 4.0 and 12.0%/year, respectively. The return on investments are negative in figure for the proposed projects, and far lower than the pre-determined cut-off rate of project evaluation criteria observed in Zambia at present.

Economic returns on investment are also negative. The net foreign exchange savings as import substitution of phosphate fertilizer are fairly large positive value for the single super phosphate project while marginal for the fused magnesium phosphate project. However it is anticipated that the savings for the fused magnesium phosphate project might be improved if the higher effectiveness of fused magnesium phosphate fertilizer is confirmed at the agronomical testings in Zambia.

The major reasons behind the conclusion are summarized as follows:

- The phosphate reserves in Chilembwe are of small scale and one can not expect the economy of scale for mining and concentration cost saving

- The origin of phosphate reserves in Chilembwe is igneous and low in P_2O_5 analysis, and intensive beneficiation and concentration processes are required to produce phosphate concentrate

- The location of phosphate reserves in Chilembwe is sited in a remote area where transport infrastructure, especially the railways system is not developed and the transport cost by road to the phosphate fertilizer plant in Kafue is excessive

- In addition to the above reasons, due to the depressed international market of phosphate concentrate at present, the domestic cost of phosphate concentrate from Chilembwe is higher than the landed cost of imported phosphate concentrate from overseas where a large scale and high quality reserves are mined at large scale operation

- The production costs of fused magnesium phosphate and single super phosphate are higher than the import substitute price of phosphate fertilizers, because of the small scale production, high costs of phosphate concentrate from Chilembwe as well as high costs of supplementary inputs such as serpentine and sulfuric acid in Zambia, and because of the depressed international market of high concentrated phosphate fertilizers such as triple super phosphate and diammonium phosphate throughout the world at present and in near future

- It should be noted that the project feasibility will not be positive in return on investment even using imported phosphate concentrate as raw material instead of domestic material from Chilembwe

- The sulfur content in single super phosphate is evaluated in product pricing as a fertilizer nutrient for sulfur deficit soil in Zambia, however effectiveness of soluble magnesia, silica and alkali in fused magnesium phosphate is not counted in product pricing because no verifiable experimental data has been developed in Zambia, so far. Therefore, the return on investment for the fused magnesium phosphate project is a little lower

- Among various product alternatives, the feasibility will be higher for the production of nitric phosphate intermediate if the modification of compound fertilizer plant at NCZ in Kafue is technically and financially possible

The proposed and studied projects are technically feasible but financially not viable and economically not justifiable as an immediate industrial and commercial project for import substitution of phosphate fertilizers in Zambia.

3.2 Recommendations

Because of the low financial and economic return on investment for the proposed projects mostly due to the depressed international market of phosphate concentrate as well as phosphate fertilizers at present and near future, the following recommendations are made:

- To wait, for the time being, the project promotion and preparation activities as an immediate industrial and commercial project in Zambia

- To continue survey and study work for the improvement of the project's potential: the discovery of larger and higher quality reserves of phosphate minerals in Zambia and the study on the production of nitric phosphate at NCZ in Kafue

- To promote the agronomical research programs in Zambia for the verification of effectiveness of not only water soluble phosphate as is stipulated in the Agriculture Act of Zambia but also citrate and citric acid soluble phosphate, soluble magnesia, silica and alkali in fertilizer to utilize various kinds of phosphate fertilizer for the diversifying and intensifying agriculture in Zambia

- To promote the efficient procurement and distribution system of fertilizer in Zambia for the agricultural development of Zambia

Table and Figure

for

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Table 2-1-1 to Table 2-1-6

and

Figure 2-1-1 to Figure 2-1-2

Table 2-1-1 CONSUMPTION OF FERTILIZER IN ZAMBIA, 1972-1985

(Unit: ton)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
COMPOUND	66,490	50,721	48,402	74,784	78,272	90,225	77,140	80,136	110,428	115,978	128,666	92,606	79,298	112,260
STRAIGHT N	44,980	32,554	50,846	56,956	65,487	75,503	50,421	61,270	82,949	93,447	82,239	69,174	58,377	91,537
STRAIGHT P	498	280	351	1,472	2,076	1,610	1,896	1,725	2,568	2,217	807	1,445	467	1,060
STRAIGHT K	832	1,226	2,751	327	39	169	149	202	219	290	108	171	214	144
TOTAL	112,800	84,781	102,350	133,695	150,774	167,507	130,077	145,368	196,363	218,791	217,868	165,798	143,894	211,180
Total in Nutrient														
N	21,922	16,325	19,473	33,044	39,828	45,283	31,100	38,263	53,170	57,766	54,396	43,616	38,144	55,729
P205	6,761	5,197	4,875	12,211	13,784	15,584	13,397	14,243	18,884	20,370	21,731	15,799	12,298	19,647
K20	4,152	3,476	4,239	5,238	4,644	5,499	5,442	4,645	5,678	6,316	8,008	6,265	4,585	7,876

Source: NAMBOARD

Table 2-1-2 SUPPLY AND CONSUMPTION OF FERTILIZER IN ZAMBIA, 1983-1986

(Unit: 1,000 ton of product)

	Production	Imports		Total Supply	Consumption
	(A)	End Products (B)	Raw Materials	(A+B)	(C)
1983	72.6	132.9	25.5	205.5	165.8
1984	77.8	195.2	23.1	273.0	143.9
1985	19.9	30.5	-	50.4	211.2
1986	59.5	143.6	N.A.	203.1	153.8

Sources: NCZ and NAMBOARD

Table 2-1-3 SALES PRICE AND PURCHASE PRICE OF FERTILIZER BY NAMBOARD

(Unit: K./ton)

	1980	1981	1982	1983	1984	1985	1986
Compound D							
Sales Price (A1)	232.0	235.0	299.0	482.0	535.0	535.0	1,600.0
Purchase Price from NCZ (B1)	-	-	612.0	611.0	611.0	664.0	1,860.0
(A1/B1) (%)	-	-	48.9	78.9	87.6	80.6	86.0
Landed Cost of Imported Fertilizer (C1)	304.0	446.0	269.0	439.3	492.3	N.I.	3,825.0*
(A1/C1) (%)	76.3	52.7	111.2	109.7	108.7	-	41.8
(B1/C1) (%)	-	-	227.5	139.1	124.1	-	48.6
Urea							
Sales Price (A2)	233.0	219.0	299.0	482.0	535.0	535.0	1,300.0
Landed Cost of Imported Fertilizer (C2)	400.0	406.0	268.0	462.6	697.4	N.A.	2,775.0*
(A2/C2) (%)	58.3	53.9	111.6	104.2	76.7	-	46.8
Ammonium Nitrate							
Sales Price (A3)	158.6	202.6	281.0	464.0	517.0	517.0	1,120.0
Purchase Price from NCZ (B3)	378.8	424.0	531.0	564.0	617.0	710.0	1,860.0
(A3/B3) (%)	41.9	47.8	52.9	82.3	83.8	72.8	60.2

Notes: A = Ex-NAMBOARD depot: Price in October in each year.
B = Ex-factory
C = C.I.F. Lusaka
N.I. = No import
N.A. = Not available
- = No production
* = As of April, 1987. (K.15/US$)

Table 2-1-4 PROJECTED DEMAND FOR PHOSPHATE FERTILIZER IN ZAMBIA

(Unit: '000 P205 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
1982	21.7	4.20	0.73	3.46	0.17	3.29	2.42	0.19	7.18	0.08
1983	15.8	3.44	0.52	3.58	0.33	1.69	1.54	0.13	4.31	0.16
1984	12.3	3.02	0.70	1.23	0.29	1.37	1.45	0.03	4.07	0.14
1985	19.6	4.29	0.97	4.95	0.32	1.63	1.42	0.22	5.47	0.39
Projected										
1986	22.9	3.9	1.3	3.5	0.4	2.7	2.9	0.2	7.8	0.2
1987	24.4	4.0	1.5	3.4	0.5	2.8	3.2	0.2	8.5	0.3
1988	25.8	4.0	1.7	3.4	0.5	3.0	3.4	0.2	9.3	0.3
1989	27.3	4.1	1.9	3.4	0.6	3.1	3.6	0.2	10.1	0.3
1990	28.8	4.2	2.0	3.4	0.6	3.3	3.8	0.2	10.9	0.4
1991	30.1	4.3	2.1	3.4	0.7	3.4	3.9	0.2	11.7	0.4
1992	31.3	4.4	2.2	3.4	0.7	3.6	4.0	0.2	12.4	0.4
1993	32.4	4.5	2.3	3.5	0.7	3.7	4.0	0.2	13.1	0.4
1994	33.7	4.7	2.3	3.6	0.7	3.8	4.1	0.2	13.8	0.5
1995	34.8	4.8	2.4	3.6	0.8	4.0	4.1	0.2	14.4	0.5
1996	36.0	5.0	2.4	3.7	0.8	4.1	4.2	0.2	15.1	0.5
1997	37.1	5.1	2.5	3.8	0.8	4.2	4.3	0.2	15.6	0.6
1998	38.1	5.3	2.5	3.9	0.8	4.3	4.3	0.2	16.2	0.6
1999	39.2	5.5	2.6	4.0	0.8	4.4	4.4	0.2	16.7	0.6
2000	40.2	5.7	2.6	4.1	0.8	4.6	4.4	0.2	17.2	0.6
2001	41.2	5.8	2.6	4.2	0.8	4.7	4.5	0.3	17.7	0.6
2002	42.3	6.0	2.7	4.3	0.8	4.8	4.6	0.3	18.1	0.7
2003	43.4	6.2	2.7	4.5	0.9	4.9	4.6	0.3	18.6	0.7
2004	44.4	6.4	2.8	4.6	0.9	5.0	4.7	0.3	19.0	0.7
2005	45.3	6.6	2.8	4.7	0.9	5.1	4.8	0.3	19.4	0.7
2006	46.1	6.8	2.8	4.8	0.9	5.2	4.8	0.3	19.8	0.7
2007	47.1	7.0	2.9	5.0	0.9	5.3	4.9	0.3	20.1	0.7
2008	48.0	7.2	2.9	5.1	0.9	5.4	5.0	0.3	20.5	0.7
2009	49.3	7.4	3.0	5.3	1.0	5.5	5.1	0.3	20.9	0.8
2010	50.1	7.6	3.0	5.4	1.0	5.6	5.1	0.3	21.3	0.8

Table 2-1-5 SALES VOLUME OF FMP IN ZAMBIA

(Unit: '000 P2O5 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
1986	9.5	1.3	1.3	1.2	0.4	0.0	2.9	0.2	2.0	0.2
1987	10.2	1.3	1.5	1.1	0.5	0.0	3.2	0.2	2.1	0.3
1988	10.8	1.3	1.7	1.1	0.5	0.0	3.4	0.2	2.3	0.3
1989	11.6	1.4	1.9	1.1	0.6	0.0	3.6	0.2	2.5	0.3
1990	12.2	1.4	2.0	1.1	0.6	0.0	3.8	0.2	2.7	0.4
1991	12.7	1.4	2.1	1.1	0.7	0.0	3.9	0.2	2.9	0.4
1992	13.2	1.5	2.2	1.1	0.7	0.0	4.0	0.2	3.1	0.4
1993	13.6	1.5	2.3	1.2	0.7	0.0	4.0	0.2	3.3	0.4
1994	14.1	1.6	2.3	1.2	0.7	0.0	4.1	0.2	3.5	0.5
1995	14.4	1.6	2.4	1.2	0.8	0.0	4.1	0.2	3.6	0.5
1996	14.8	1.7	2.4	1.2	0.8	0.0	4.2	0.2	3.8	0.5
1997	15.3	1.7	2.5	1.3	0.8	0.0	4.3	0.2	3.9	0.6
1998	15.6	1.8	2.5	1.3	0.8	0.0	4.3	0.2	4.1	0.6
1999	15.9	1.8	2.6	1.3	0.8	0.0	4.4	0.2	4.2	0.6
2000	16.2	1.9	2.6	1.4	0.8	0.0	4.4	0.2	4.3	0.6
2001	16.5	1.9	2.6	1.4	0.8	0.0	4.5	0.3	4.4	0.6
2002	17.0	2.0	2.7	1.4	0.8	0.0	4.6	0.3	4.5	0.7
2003	17.5	2.1	2.7	1.5	0.9	0.0	4.6	0.3	4.7	0.7
2004	17.8	2.1	2.8	1.5	0.9	0.0	4.7	0.3	4.8	0.7
2005	18.2	2.2	2.8	1.6	0.9	0.0	4.8	0.3	4.9	0.7
2006	18.4	2.3	2.8	1.6	0.9	0.0	4.8	0.3	5.0	0.7
2007	18.7	2.3	2.9	1.7	0.9	0.0	4.9	0.3	5.0	0.7
2008	19.0	2.4	2.9	1.7	0.9	0.0	5.0	0.3	5.1	0.7
2009	19.7	2.5	3.0	1.8	1.0	0.0	5.1	0.3	5.2	0.8
2010	19.8	2.5	3.0	1.8	1.0	0.0	5.1	0.3	5.3	0.8

Table 2-1-6 SALES VOLUME OF SSP IN ZAMBIA

(Unit: '000 P205 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
1991	9.03	1.29	0.63	1.02	0.21	1.02	1.17	0.06	3.51	0.12
1992	9.39	1.32	0.66	1.02	0.21	1.08	1.20	0.06	3.72	0.12
1993	9.72	1.35	0.69	1.05	0.21	1.11	1.20	0.06	3.93	0.12
1994	10.11	1.41	0.69	1.08	0.21	1.14	1.23	0.06	4.14	0.15
1995	10.44	1.44	0.72	1.08	0.24	1.20	1.23	0.06	4.32	0.15
1996	10.80	1.50	0.72	1.11	0.24	1.23	1.26	0.06	4.53	0.15
1997	11.13	1.53	0.75	1.14	0.24	1.26	1.29	0.06	4.68	0.18
1998	11.43	1.59	0.75	1.17	0.24	1.29	1.29	0.06	4.86	0.18
1999	11.76	1.65	0.78	1.20	0.24	1.32	1.32	0.06	5.01	0.18
2000	12.06	1.71	0.78	1.23	0.24	1.38	1.32	0.06	5.16	0.18
2001	12.36	1.74	0.78	1.26	0.24	1.41	1.35	0.09	5.31	0.18
2002	12.69	1.80	0.81	1.29	0.24	1.44	1.38	0.09	5.43	0.21
2003	13.02	1.86	0.81	1.35	0.27	1.47	1.38	0.09	5.58	0.21
2004	13.32	1.92	0.84	1.38	0.27	1.50	1.41	0.09	5.70	0.21
2005	13.59	1.98	0.84	1.41	0.27	1.53	1.44	0.09	5.82	0.21
2006	13.83	2.04	0.84	1.44	0.27	1.56	1.44	0.09	5.94	0.21
2007	14.13	2.10	0.87	1.50	0.27	1.59	1.47	0.09	6.03	0.21
2008	14.40	2.16	0.87	1.53	0.27	1.62	1.50	0.09	6.15	0.21
2009	14.79	2.22	0.90	1.59	0.30	1.65	1.53	0.09	6.27	0.24
2010	15.03	2.28	0.90	1.62	0.30	1.68	1.53	0.09	6.39	0.24

Figure 2-1-1 FLOW OF FERTILIZER DISTRIBUTION

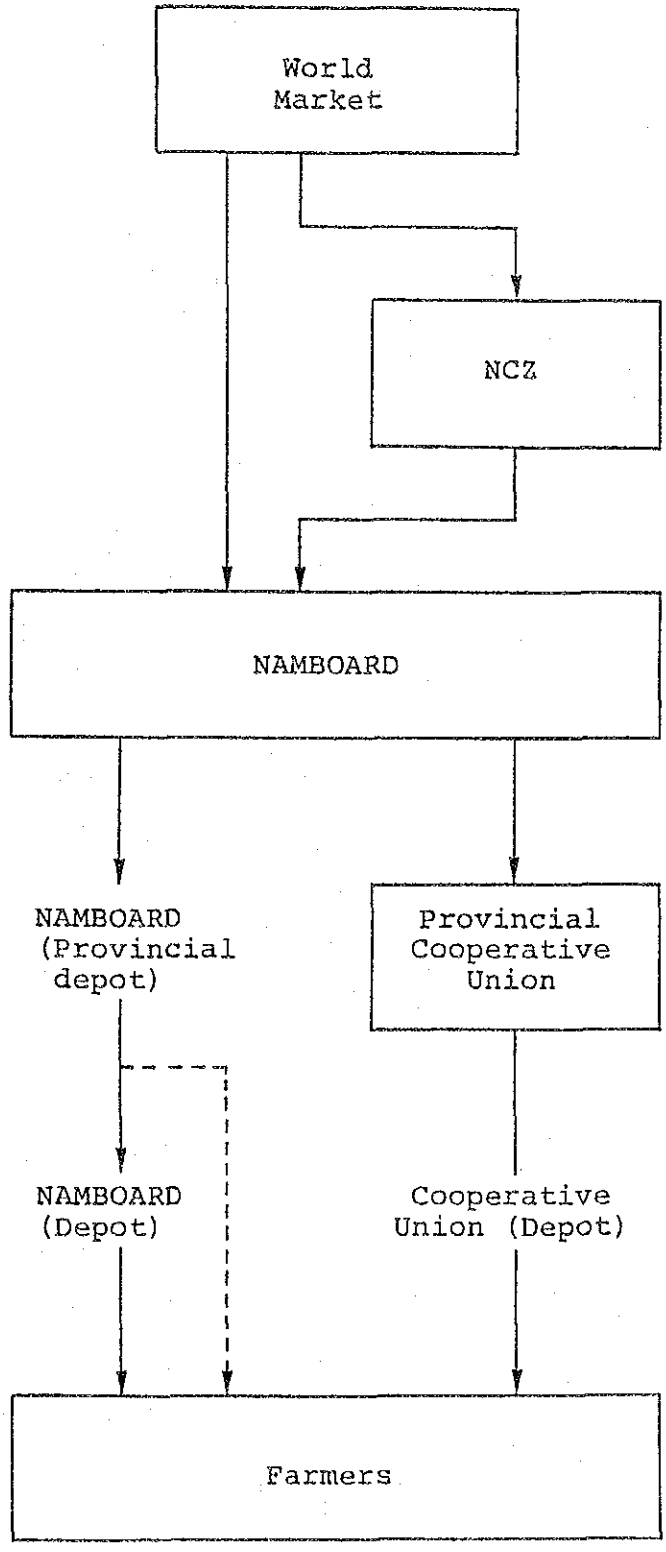
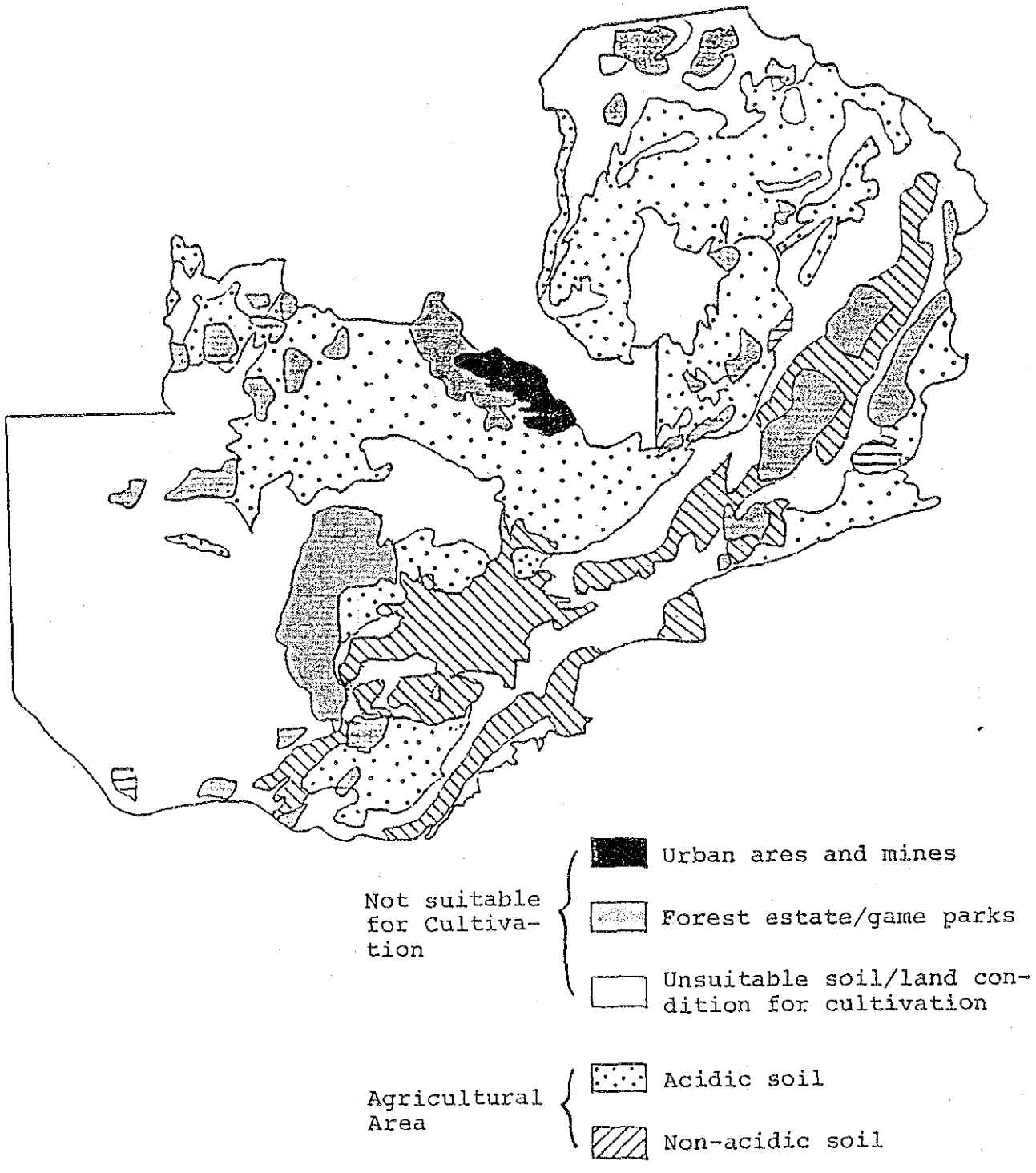


Figure 2-1-2 CLASSIFICATION OF AREA IN VIEW OF USE OF FMP AND LIME



PART I
INTRODUCTION

Part I INTRODUCTION

Chapter 1 OBJECTIVES AND SCOPE OF THE STUDY

1.1 Background and Objectives

The Government of the Republic of Zambia (GRZ) envisages to establish a phosphate fertilizer plant, the first phosphate fertilizer manufacturing project in the Republic.

The economy of Zambia has been heavily dependent on copper mines, but since the sharp decline of copper exporting price in 1974, Zambia's development strategy has given high priority to agricultural and rural development, especially to achieve self-sufficiency in major foodstuffs, particularly maize, cassava and sorghum.

The agriculture sector currently contributes about 15% of the gross domestic product (GDP), about 10% of industrial formal employment and 65% of gross population in the country. Fertilizers are the most important agricultural inputs required for the production increase.

In Zambia, there is a nitrogen fertilizer plant of Nitrogen Chemicals of Zambia Ltd. (NCZ) in Kafue, and is producing ammonium nitrate, ammonium sulfate and compound fertilizers using domestic coal and pyrite as major inputs but all requirements of phosphate and potash fertilizers are fulfilled by import. The consumption of fertilizer of Zambia in 1984 is 140,700 tons (Nitrogen as N; 35,250 tons, Phosphate as P_2O_5; 13,200 tons, Potash as K_2O; 4,800 tons and Total Nutrients; 53,250 tons) and serves as the most essential input for the agricultural and economic developments of the Republic.

The GRZ is interested in promoting the domestic production of phosphate fertilizers for import substitution by utilizing phosphate concentrate which will be mined and concentrated at Chilembwe, Zambia and utilizing domestically available hydroelectricity, serpentine or sulfuric acid as supplementary inputs. The phosphate reserve has been found in Chilembwe during exploration works of MINEX in 1980. The deposit is igneous type and consists of syenite and carbonatites. In 1984, Japan International Cooperation Agency has undertaken, in accordance with the request of the Zambian Government, a mining and

concentration study and the results were summarized in "A Pre-Feasibility Study for the Phosphate Development Project, the Republic of Zambia, 1985". The size of reserve is rather limited and will serve 10,554 TPY of P_2O_5 supply over 14 years of project life.

Within this context, the GRZ has requested the Government of Japan to provide further technical assistance for conducting a feasibility study on the establishment of a fused magnesium phosphate fertilizer plant in the Republic of Zambia, under the technical cooperation program of the Government. In response to the request, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation program, dispatched the Preliminary Survey Team, led by Mr. Keiji Miura of JICA on August 12, 1986.

As a result, an agreement was made on August 19, 1986 between JICA and INDECO Ltd., as the Coordinating Body as well as the Counterpart Agency for the Study in Zambia, setting forth the Scope of Work for the feasibility study. Present study thus has been undertaken in accordance with the Scope of Work and the study results are summarized in the Report.

1.2 Scope of the Study

The scope of the study set forth in the agreement, is for detailed market, technical as well as financial and economic studies, which broadly consists of the following aspects:

- S/W-1 Background and Relevant Condition
- S/W-2 Fertilizer Market and Distribution System in Zambia
- S/W-3 Raw Materials and Utilities Availability
- S/W-4 Project Site
- S/W-5 Conceptual Design
- S/W-6 Construction Cost
- S/W-7 Financial Analysis
- S/W-8 Economic Evaluation
- S/W-9 Conclusion and Recommendations

The full text of the Scope of Work (S/W) is attached as reference in Annex I-1 of the Report.

1.3 Methodology and Schedule

In the course of the study, a JICA Study Team headed by Dr. Shigeo Ueki and consisting of eight other experts visited Zambia for field survey from November 25, 1986 to December 20, 1986. To assist the Study Team during the field survey, the Counterpart members were assigned from staffs of INDECO which is the counterpart agency as well as the coordinating body for the feasibility study. The Study Team, with the assistance of the Counterpart, carried out collection and analysis of necessary sample, data and information, investigation of the pre-selected plant sites as well as on-the-spot survey on fertilizer application, distribution and marketing and other relevant industries in the Republic.

At concluding the field survey, the Study Team submitted a Progress Report to summarize the major findings and issues identified during the field works and to present the major basis and assumptions for the feasibility study. The presentation results of the Progress Report is documented in a Minutes of Meeting, dated on December 19, 1986.

The draft report of the feasibility study was presented to the Counterpart officers from INDECO during their training program of JICA in June 1987 in Japan and also officially presented to INDECO, Zambia in July, 1987.

Members list of the JICA Study Team, the Coordinating Body and Counterpart, offices and persons visited by the Study Team and the field surveys schedule in Zambia are attached as Annex I-2, I-3, I-4 and I-5.

In light of the scope and depth of the study, the major areas to be examined, specifically to the proposed project are classified as follows:

- Marketing and Distribution of Fertilizer, and Agronomic Features of Zambian Agriculture

- Raw Materials and Utilities Suppliability, and Product Alternatives and Site Selections

- Project Financial Analysis and Economic Evaluation

General features of the study of these areas are explained below:

1.3.1 Marketing and Distribution of Fertilizer

The study was made by giving primary attention to analyzing the present situation of agriculture and fertilizer consumption in Zambia, and forecasting the outlook of future demand for fertilizer and possible sales of the fertilizer alternative products from the project. In the meanwhile, studies were made on the systems in use for the marketing and distribution of fertilizer and also on underlying constraints for fertilizer movement in the country, and based on those studies, examinations were made of efficient systems and facilities which are required or are needed for successful operation of the marketing and distribution of phosphate fertilizer produced at the project as well as the traditional imported fertilizers and domestically produced fertilizer at existing fertilizer plant.

Careful examination was tried to analyze the climatic, soil and cropping characteristics of Zambian agriculture.

In addition to the above, the Study Team attempted to predict the future tendency of international supply/demand balance analysis as well as prices of fertilizer, which were used as a basis for the financial and economic evaluation of the project. The outcome of these studies is described in Part II of the Report.

1.3.2 Technical Study

The objective of the study is to investigate the technical and financial feasibility of the establishment of a plant for the production of fused magnesium phosphate as a primarily product alternative with utilization of phosphate concentrate from Chilembwe and serpentine from Mkushi as well as a plant for the production of single super phosphate as a secondary product alternative with utilization of phosphate concentrate from Chilembwe and sulfuric acid from NCZ, Kafue and/or ZCCM, Copperbelt.

The availability of raw materials, utilities, site selections among Kafue, Kabwe, Ndola and Kitwe, and marketability of product alternatives should be integrated to formulate the optimal production scheme.

Based on those studies and investigations, examinations were made to develop the optimum plan for the project and draw up conceptional designs for the plants and

facilities required. Further, examinations were also made to formulate an efficient plan for the implementation and management of the project so as to meet the conditions prevailing in the country. The outcome of those studies, investigations and examinations is described in Part III of the Report.

1.3.3 Financial Analysis and Economic Evaluation

The financial projections and analysis as well as economic evaluation of the project were undertaken in following steps:

- To estimate the total financing required and formulate the optimum financing plan for the project
- To estimate the production cost and sales revenue
- To assess the quantitative and qualitative benefits and costs which are derived from the proposed projects
- To analyze the integrated analysis on financial viability and soundness as well as the economic justification of the project

The outcome of those analysis and assessment are described in Part IV of the Report. Overall study schedule and study flow are illustrated in Figure I-1 and I-2, respectively.

Chapter 2 BACKGROUND OF THE PROJECT

2.1 Industrial Development of Zambia

2.1.1 Geography

The Republic of Zambia is a land-locked country with 753,000 km^2 area on the Great Central Africa Plateau with average altitude between 1,000 to 1,300 meters and is surrounded by Zaire and Tanzania in the North, Malawi and Mozambique in the East, Zimbabwe and Botswana in the South, Nambia in South-West, and Angola in the West.

Lying between 8 and 18 degree latitude south, and 22 and 34 degree longitude east, Zambia has tropical climate and vegetation. There are three distinct seasons: warm and wet season from November through April, cool and dry season from May to August, and hot and dry season during September to October.

Annual rain precipitation in the North is from 1,100 to 1,400 mm while in the South is between 600 to 1,100 mm. Major vegetations are savanna in the main plateau which is a mixture of trees, tall grass and herbs. In the Southern and Lusaka Provinces, maize farming is widely spread. Forests occur in the Northwest and Western parts of the country. Thick forests are found in the North and grasslands are observed in the seasonal flooded plains of Western Province, the Kafue Flat and Bangwulu Swamps.

The population of Zambia is recorded at 5.66 millions with life expectancy of 50.4 years for males and 52.5 years for females in the 1980 Census and is estimated 6.73 millions in 1985. Population increase rate in Zambia is considered one of the highest in the world. Average annual growth rate during the intercensal period of 1969 to 1980 was 3.1% and future population is projected to increase to 8.1 millions in 1990 and 11.8 millions by the year 2000.

2.1.2 The Economy

The gross domestic product (GDP) rose from ZK3.06 billions in 1980 to ZK12.10 billions in 1986 in terms of current price, giving an average annual growth rate of 25.8%. However, in constant price in terms of ZK, the growth during the period is a marginal 0.4% and in terms of US$ the rate is (-) 20.6% per year. In view of the high population increase, the GDP per capita in terms of constant price in ZK is negative during the period.

The employment population in the whole industrial formal sectors is only 5.2% of total population and the number of formal employees is declining despite the population increase. The majority of population, therefore, is dependent on agriculture in rural area of Zambia. The trend of GDP and relevant basic data in Zambia is illustrated in Table I-1.

Table I-2 illustrates the sectoral composition trend of the GDP from 1980 to 1986. Despite the encouraging counter measures for the agricultural developments taken by the Government, the agricultural sector is declining in the GDP ratio in current price during last three years. The ratio in 1986 is 10.8% for agriculture, 24.6% for mining, 20.1% for manufacturing, 10.7% for trade and 8.5% for financing and business services.

The GDP among the supply of resources in 1986 is 81.5% which has increased from 73.7% in 1980 while the import of goods and services has decreased from 26.2% to 18.5 during the period. At a same time, the ratio of export of goods and services has decreased from 23.4 to 21.7%. The Government and private consumptions of use of resources are 74.6 and 19.4%, respectively in 1986. Table I-3 illustrates the ratio of resources supply and use in Zambia from 1980 to 1986.

2.1.3 Development Policy of Zambia

The latest economic policy of Zambia is summarized in "Economic Review 1986 and Annual Plan 1987, by National Commission for Development Planning" which states that since 1983 the government undertook a number of economic policy reforms with a view of resuscitating the economy. These includes decontrol of prices, introduction of foreign exchange auction, reduction of subsidies for food and other commodities, increases in the producer prices of agricultural commodities and the liberation of agricultural marketing.

Although there have been partial benefits of such liberation and structural adjustment programs, the overall economic situation have not yet been improved. The external debt service burden is nearly equal to the country's foreign exchange earnings.

The budget deficit of the Government in 1986 is almost a quarter of the GDP and the domestic inflation rates of consumer prices in 1985 and 1986 are 30 and 60%, respectively. The gross fixed capital formation in 1986 has dropped to

7.0% of the GDP: the all time lowest in Zambia which is confined to rehabilitation of existing capital stock in mining, manufacturing and transport sectors.

The foreign exchange rate has been depreciated almost one tenth from ZK2.20/US$ before the introduction of auction system in October, 1985 to the ZK21.01/US$ in April 25, 1987. The Government finally re-introduced the fixed rate system on May 01, 1987 to appreciate exchange rate to ZK8.00/US$.

In line with the various economic problems, the Government has established following six major developing policies for the annual plan objectives and sectoral priorities in 1987:

- Increased investments to improve agricultural production and agro-based industries
- Creating employment opportunities in agriculture
- Stabilize the consumer price and reduce domestic inflation
- Stabilize the foreign exchange rate and improve the non-traditional exports
- Reduce the Government budget deficit by reducing subsidies and civil services
- Readjust external technical assistance to fulfill the requirements of highly-skilled manpower

2.2 Importance of Agriculture in Zambian Economy

The most important agricultural product in Zambia is maize which is the principal foodstuffs of the Republic. Besides maize, wheat, cotton, tobacco, groundnuts, sunflower, beef, pork and milk are the major produce in Zambia. Marketable surplus tends to fluctuate greatly due to the fact that approximately two third of population is engaged in essentially subsistence agriculture: producing and captively consuming. The farm management in Zambia is broadly classified into three: commercial farmers, emergent farmers (semi-commercial) and small-scale farmers (traditional).

The share of crop production from commercial sector and small holders are considered that almost all production of tobacco, sugar, wheat and soybean are produced by commercial farmers, and almost all of groundnuts and cotton are by small holders. The maize, sunflower and paddy are evenly distributed between the two, more specifically, maize is produced 40% by commercial farmers and 60% by small holders. The total production and marketed maize in 1986/7 is estimated 15.0 and 11.0 million bags (net weight of 90 kg/bag), respectively.

The total land area of Zambia is 74.1 million Ha and at present 7.0% is used as arable land and 47.2% is used as permanent pasture. It is estimated that total potential arable land and irrigation land are 32.0 and 10.0 million Ha, respectively. Historical trend of marketed agricultural production is recorded in Table I-4.

Despite the great potential of agricultural production in Zambia, the consumption of fertilizer per Ha of agricultural land as well as per capita is still one of the lowest in the world. The price of agricultural produce and fertilizer retail price has been controlled by the government as is shown in Table I-5. In view of the recent basic policy of the Republic, the price of fertilizer is increasing at a higher rate than the agricultural producer's prices which will discourage the fertilizer uses in Zambia. It is estimated that over 90% of fertilizer is consumed for maize in Zambia and the ratio of producer's price of maize and retail price of fertilizer is the key index for fertilizer uses in Zambia.

The Annual Plan 1987 stresses the priority investments in following agricultural sector:

- Crop and livestock production
- Extension program and projects
- Providing essential imports: fertilizer, machinery, farm implements and pesticides
- Full utilization of already cultivated area
- Providing irrigation facilities
- Providing animal health and disease control

2.3 Economic Significance of the Proposed Project

Phosphate fertilizer is one of the most important inputs for the Zambian agriculture. In Zambia there is one nitrogen fertilizer plant but no existing phosphate fertilizer manufacturer, and the requirements for phosphate fertilizer therefore are met by imports. Zambian has been spending scarce foreign exchange for commercial importation of fertilizer, while receiving some fertilizer supplied on official grants.

The geographic conditions of Zambia cause high costs for importation, so the prices for imported fertilizers are higher than international market prices. Another problem is the difficulty in procuring fertilizer in time and delivering to farmers when required. If phosphate fertilizer is locally produced at reasonable cost, it would not only contribute to the country's foreign exchange savings, but also would assure stable supply of phosphate fertilizer. Hence it is expected that the present project may contribute to the development of agriculture and eventually economic growth of the country.

In addition, the project would contribute to efficient utilization of indigenous resources, because the project envisages efficient uses of domestic igneous phosphate resources and hydroelectric power. Further, impacts on the country's industrial development which the project could have are also beneficial, because the country at present is still at an infant stage of industrialization. The manufacturing technologies which form the basis for the project are basic technologies applicable to other industries and therefore could provide fundamental experiences beneficial for developing various industries of Zambia in future.

Table and Figure

for

Part I

INTRODUCTION

Table I-1 to Table I-5

Figure I-1 to Figure I-2

Table I-1 TREND OF GROSS DOMESTIC PRODUCT IN ZAMBIA

Items	Unit	1980	1981	1982	1983	1984 (Preliminary)	1985 (Preliminary)	1986 (Provisional)
Gross Domestic Product (GDP)								
- Current Price	ZK, Billions	3.06	3.49	3.60	4.18	4.93	7.05	12.10
	US$, Billions	3.81	3.95	3.87	2.77	2.24	1.24	0.95
- Constant Price - 1977	ZK, Billions	2.00	2.12	2.06	2.02	2.01	2.04	2.05
- Annual Change	%/Year	-	6.0	(-)2.8	(-)1.9	(-)0.5	1.5	0.5
Per Capita GDP								
- Current Price	ZK	541	587	584	671	764	1,055	1,759
	US$	674	664	628	444	345	185	138
- Constant Price - 1977	ZK - 1977	354	356	334	324	311	305	297
- Annual Change	%/Year	-	0.8	(-)6.2	(-)3.0	(-)4.0	(-)1.9	(-)2.6
Population	Millions	5.65	5.96	6.16	6.23	6.45	(6.68)	(6.88)
- Agricultural Population	Millions	3.76	3.93	4.02	4.03	4.12	(4.21)	(4.30)
- Employees in Industry	Millions	0.381	0.373	0.367	0.364	0.365	0.361	0.360
Formal Sector								
- Agriculture Sector	Millions	0.033	0.036	0.053	0.035	0.035	0.035	0.035
Exchange Rate	ZK/US$	0.803	0.883	0.930	1.511	2.201	5.70	12.71
Deflator (100=1977)	%/Year	0.654	0.607	0.572	0.483	0.408	0.289	0.169

Sources: - Economic Review 1986 and Annual Plan 1987, NCDP, January, 1987
- Bank of Zambia 1985, BOZ, 1986

Table I-2 SECTORAL COMPOSITION OF GROSS DOMESTIC PRODUCT IN ZAMBIA

(Unit: % in Current Price)

Industrial Sector	Unit	1980	1981	1982	1983	1984 (Preliminary)	1985 (Preliminary)	1986 (Provisional)
1. Primary	%							
- Agriculture, Forestry and Fishing		14.1	15.7	13.5	14.0	14.5	13.1	10.8
- Mining and Quarrying		16.2	13.9	10.9	15.2	13.7	15.6	24.6
2. Secondary	%							
- Manufacturing		18.3	19.4	20.4	19.6	20.5	22.8	20.1
- Electricity and Water		2.0	1.9	2.0	1.7	1.4	1.0	0.6
- Construction		4.4	3.2	3.5	3.1	3.1	2.6	2.5
3. Tertiary	%							
- Trade, Hotel and Restaurants		11.7	11.7	12.5	12.4	13.2	13.6	10.7
- Transport and Communication		5.2	4.9	5.3	5.4	5.1	4.9	4.9
- Financial and Business Services		9.4	9.2	10.0	9.6	10.5	9.7	8.5
- Community and Social Services		15.1	16.7	18.3	16.2	6.5	5.6	4.0
4. Custom Duty on Final Demand	%	3.6	3.4	3.6	2.2	2.8	4.7	8.6
5. Inputed Bank Charges	%	1.0	1.0	1.0	1.0	1.9	0.9	0.9
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sources: - Economic Review 1986 and Annual Plan 1987, NCDP, January, 1987
- Bank of Zambia 1985, BOZ, 1986

Table I-3 RATIO OF RESOURCES SUPPLY AND USES IN ZAMBIA

Resources	Unit	1980	1981	1982	1983	1984 (Preliminary)	1985 (Preliminary)	1986 (Provisional)
1. Supply of Resources	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
GDP at Market Prices		73.7	78.0	81.6	83.7	84.0	82.8	81.5
Import of Goods and Services		26.2	22.0	18.4	16.3	16.0	17.2	18.5
2. Use of Resources	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Domestic Use		76.6	80.2	76.4	74.0	76.8	81.3	74.6
- Government Consumption		19.6	22.5	21.4	18.9	20.2	18.7	19.4
- Private Consumption		40.8	43.3	43.1	45.8	46.5	52.0	42.9
- Fixed Capital Formation		12.7	13.0	12.3	10.3	8.8	8.1	7.2
- Change in Stocks		3.5	1.4	(-)0.4	(-)0.9	1.3	2.5	5.1
Export of Goods and Services		23.4	20.3	25.3	22.9	22.4	20.5	21.7
Statistical Discrepancy		0.0	(-)0.5	(-)1.7	2.1	0.8	1.8	3.7

Sources: - Economic Review 1986 and Annual Plan 1987, NCDP, January, 1987
- Bank of Zambia 1985, BOZ, 1986

Table I-4 MARKETED AGRICULTURAL PRODUCTION AND FERTILIZER CONSUMPTION IN ZAMBIA

Crops and Fertilizer	Unit	1980	1981	1982	1983	1984 (Preliminary)	1985 (Preliminary)	1986 (Provisional)
1. Cereals	TPY, Thousand							
Maize		383.0*	693.3	508.3	530.6	571.2	648.0	954.0
Wheat		6.6	11.5	12.5	10.0	4.4	2.8	1.4
Paddy Rice		2.5	2.7	2.8	5.9	5.4	7.3	5.6
2. Oil Seeds	TPY, Thousand							
Soya Bean		2.0	3.7	5.1	7.0	9.5	10.9	25.1
Sunflower		28.3	19.2	20.3	31.4	40.1	25.6	26.9
Groundnuts		2.0	1.3	0.8	1.0	1.1	2.4	6.3
3. Others	TPY, Thousand							
Seed Cotton		15.0	17.2	13.2	32.0	40.9	30.3	33.4
Sugar Cane		920.0	893.0	1,010.0	1.086.1	1.179.0	1,207.0	na
Tobacco		4.6	2.9	2,6	2.8	3.1	2.7	4.0
Tea Leaf		0.1	0.4	0.4	0.4	0.4	1.8	na
4. Fertilizer	TPY, Thousand							
Sales by NAMBOARD**		196.1	211.6	211.8	165.8	140.7	na	na
Purchases by NAMBOARD**		191.0	175.2	294.1	140.7	215.1	na	na

Sources: - Economic Review 1986 and Annual Plan 1987, NCDP, January, 1987
- Bank of Zambia 1985, BOZ, 1986

* Production drop due to severe drought in the year, the production in 1975 is 559.0 TPY, Thousands.
** NAMBOARD: a parastatal organization under the Company Act and established through Parliamentary Statutes and wholly owned by the Government, is the only organization for procurement, storage and distribution of fertilizers in Zambia.

Table I-5 AGRICULTURAL PRODUCER'S PRICE OF CROPS AND COST OF FERTILIZERS

(Unit: ZK/Unit)

Crops and Fertilizer	Unit in kg	1980	1981	1982	1983	1984 (Preliminary)	1985 (Preliminary)	1986 (Provisional)
1. Agricultural Products								
Maize, Bags	90	11.70	13.50	16.00	18.30	24.50	28.32	55.00
Shelled Groundnuts, Bags	80	35.00	42.70	48.00	55.00	71.50	91.67	131.35
Sunflower, Bags	50	16.40	17.60	20.75	21.50	21.50	27.88	41.95
Soyabeans, Bags	90	32.00	36.30	42.21	45.30	52.50	60.90	112.10
Wheat, Bags	90	20.00	26.00	32.00	35.75	42.50	45.20	86.40
Paddy Rice, Bags	80	18.00	18.60	28.00	40.00	40.00	40.00	55.57
Sorghum, Bags	90	6.00	9.00	9.00	16.00	18.65	26.90	31.35
Millet, Bags	90	6.00	6.00	6.00	29.00	29.50	38.10	56.25
Virginia Tabocco	1	1.57	1.65	2.40	2.70	2.80	3.45	5.12
Burley Tobacco	1	-	-	-	-	-	2.30	3.50
Seed Cotton	1	0.46	0.46	0.47	0.52	0.58	0.67	0.99
2. Fertilizers								
Urea, Bags	1,000	233	233	219	299	482	535	1,260
Ammonium Nitrate, Bags	1,000	156	158	201	281	464	569	1,120
Compound Fertilizer "D"*, Bags	1,000	232	295	299	482	535	535	1,600

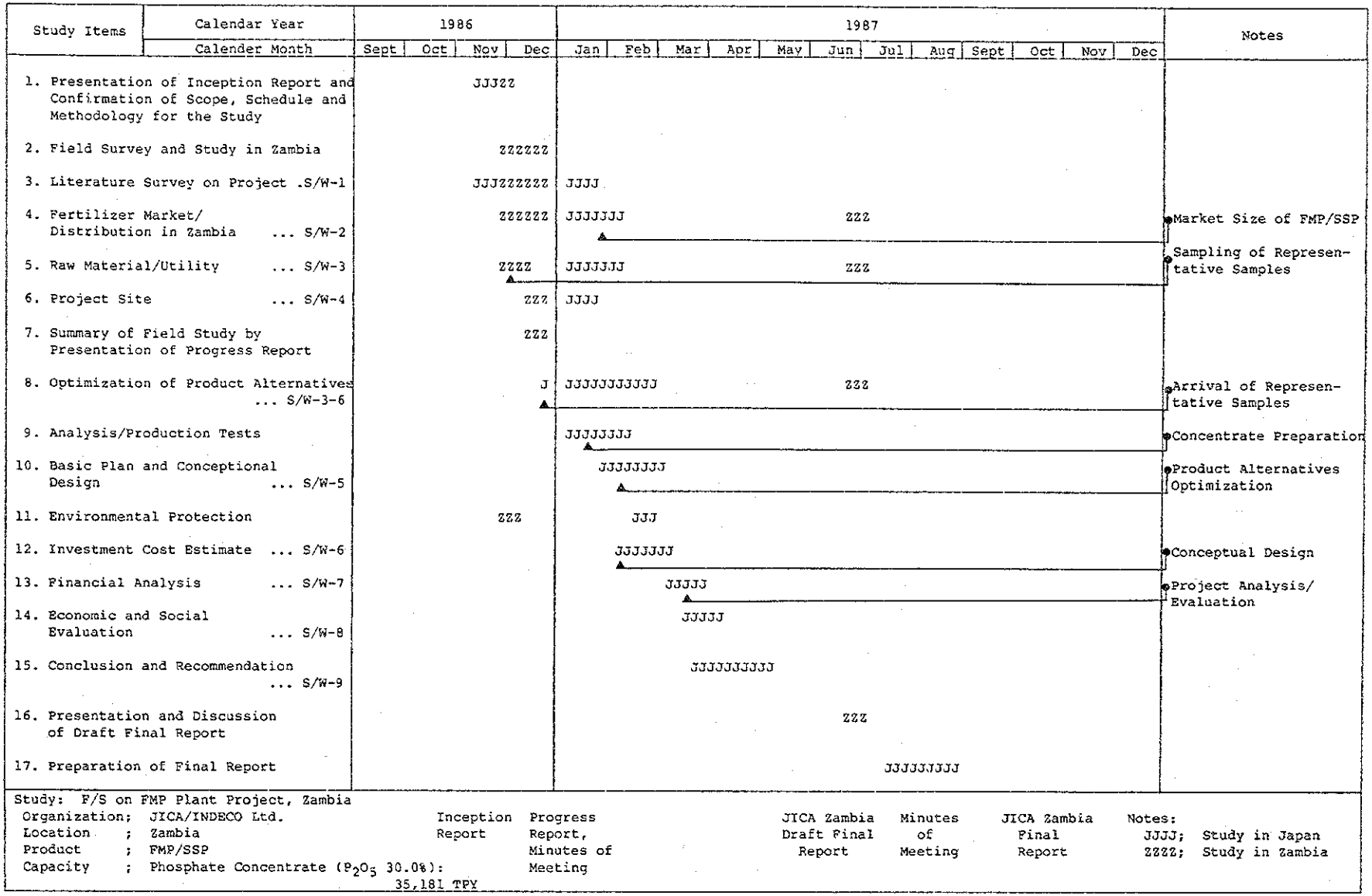
Sources: - Economic Review 1986 and Annual Plan 1987, NCDP, January, 1987
- Bank of Zambia 1985, BOZ, 1986

* Compound Fertilizer "D" is the best selling fertilizer in 1984 (73,000 TPY) with nutrient analysis of (10-20-10-11)

Figure I-1 FEASIBILITY STUDY SCHEDULE

- The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia -

1986/1987
Japan International Cooperation Agency
Tokyo, Japan



Study: F/S on FMP Plant Project, Zambia
Organization; JICA/INDECO Ltd.
Location ; Zambia
Product ; FMP/SSP
Capacity ; Phosphate Concentrate (P_2O_5 30.0%): 35,181 TPY

Inception Report
Progress Report, Minutes of Meeting
JICA Zambia Draft Final Report
Minutes of Meeting
JICA Zambia Final Report

Notes:
JJJJ; Study in Japan
ZZZZ; Study in Zambia

A/W-1 Presentation of Inception Report

- Confirmation of Scope, Schedule and Methodology
- Raw Material Supply and Sampling
- Product Mix
- Site Alternatives by INDECO/Selection Criteria
- Basis of Financial/Economic Analysis
- Product Evaluation (Chem, Soil, Crop and Field)
- Available Data on Soil: pH, S, MgO, and B
- Electricity Supply and Pricing (Financial/Economic)
- Assignment of Counterpart Members and Coordination Procedure

S/W-1 Literature Survey on Fertilizer and Project

- World Supply/Demand/Price of Fertilizer
- Agriculture in Zambia
- Fertilizer in Zambia
  - Industry - Supply/Demand/Consumption
- Electricity in Zambia
  - Supply/Consumption/Pricing (Financial/Economic)
- Policy and Institutions for Development
- Fertilizer Control Order, Regulation, Registration and Official Analysis
- Review of Pre-F/S Report for Phosphate Development Project in Zambia - 1985 by JICA

S/W-2 Fertilizer Market and Distribution in Zambia

- Supply/Consumption/Pricing
- Transportation Channel/Cost
- Import and Pricing
- Subsidies
- Regional and Crop-Wise Consumption
- Supply/Demand Projection up to 1986 (10 Years)
- Analysis of Marketing/Distribution System
- Proposal for Marketing/Distribution for the Project

A/W-2 Climatic, Soil, Crop and Farm Management, Financing, Tax, Incentives and Project Implementation

S/W-3 Raw Material and Utility Supply

- Electricity : Capacity/Pricing/Transmission/Distribution/Consumption/LRMC
- Raw Water : Capacity/Quality/Pricing/Facilities
- Phos Concentrate : Reserve/Concentration/Pricing/Quality/Quantity/Schedule/Transport
- Others : Dolomite/Silica/Serpentine/Molasses/Sulfuric Acid/Nitric Acid/Ammonia/Lime/Fuel Oil/Bag
- Production Tests: Phos Concentrate/FMP/SSP
- Sampling and Forwarding of Representative Samples

S/W-4 Site Conditions

- Site Alternatives by INDECO
- Natural Conditions: Meteorology/Geology/Topography
- Socio-Economic Conditions: Population/Labour/Wage/Regional Development/Utilities/Infrastructure
- Comparison Criteria/Evaluation/Selection
- Plant Management and Technical Skill
- Related Industry: Maintenance Works
- Local Specific Conditions
- Local Transport
- Local Procurement, Availability and Pricing

A/W-3 Environmental Protection

- Law, Regulation, Institution, Management in Zambia
- Protection Countermeasure
- Standards (Zambia, USA, Europe and Japan)
- Air/Water/Solid/Noise Standards
- Fluoride Chemicals Marketability in Zambia
  - CaF_2 - MgF_2 - Na_2SiF_6 and others

Step 1: Preparatory Work in Japan

Step 2: Field Work in Zambia

Figure I-2 FEASIBILITY STUDY COMPONENTS AND FLOW

- The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia -

S/W-1 Literature Survey on Fertilizer and Project

- World Supply/Demand/Price of Fertilizer
- Agriculture in Zambia
- Fertilizer in Zambia
  - Industry
  - Supply/Demand/Consumption
- Electricity in Zambia
  - Supply/Consumption/Pricing (Financial/Economic)
- Policy and Institutions for Development
- Fertilizer Control Order, Regulation, Registration and Official Analysis
- Review of Pre-F/S Report for Phosphate Development Project in Zambia - 1985 by JICA

S/W-2 Fertilizer Market and Distribution in Zambia

- Supply/Consumption/Pricing
- Transportation Channel/Cost
- Import and Pricing
- Subsidies
- Regional and Crop-Wise Consumption
- Supply/Demand Projection up to 1986 (10 Years)
- Analysis of Marketing/Distribution System
- Proposal for Marketing/Distribution for the Project

A/W-2 Climatic, Soil, Crop and Farm Management, Financing, Tax, Incentives and Project Implementation

S/W-3 Raw Material and Utility Supply

- Electricity : Capacity/Pricing/Transmission/Distribution/Consumption/LRMC
- Raw Water : Capacity/Quality/Pricing/Facilities
- Phos Concentrate : Reserve/Concentration/Pricing/Quality/Quantity/Schedule/Transport
- Others : Dolomite/Silica/Serpentine/Molasses/Sulfuric Acid/Nitric Acid/Ammonia/Lime/Fuel Oil/Bag
- Production Tests: Phos Concentrate/FMP/SSP
- Sampling and Forwarding of Representative Samples

S/W-4 Site Conditions

- Site Alternatives by INDECO
- Natural Conditions: Meteorology/Geology/Topography
- Socio-Economic Conditions: Population/Labour/Wage/Regional Development/Utilities/Infrastructure
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- Related Industry: Maintenance Works
- Local Specific Conditions
- Local Transport
- Local Procurement, Availability and Pricing

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- Law, Regulation, Institution, Management in Zambia
- Protection Countermeasure
- Standards (Zambia, USA, Europe and Japan)
- Air/Water/Solid/Noise Standards
- Fluoride Chemicals Marketability in Zambia
  - CaF_2 - MgF_2 - Na_2SiF_6 and others

A/W-4 Summary of Field Study by Progress Report Presentation

- Summary of Study Results
- Confirmation of Scope of Home Office Work in Japan
- Representative Sample
- Raw Material/Process/Product Mix/Project/Capacity/Pricing
- Product Mix Selection Criteria
- Marketability of FMP/SSP
- Basis of Financial/Economic Analysis
- Confirmation of Comments of Counterpart Agency
- Preparation of Minutes of Meeting

S/W-3-6 Raw Material Analysis and Production Tests (Phos Concentrate/FMP/SSP)

- Raw Material Analysis (Chem/Mineralogy)
- Phos Concentration (Small Scale/Batch Wise)
- Production Tests (FMP/SSP: Small Scale/Batch Wise)
- Product Evaluation (Official Method: Zambia/USA/Japan/Europe)
- Product Physical Property
- Product Mix Comparative Evaluation (Raw Material/Process/Cost/Marketability)
- Presentation of Production Test Samples (Phos Concentrate/FMP/SSP)

A/W-5 Optimization Study of Product Alternatives

- Product Alternatives (Phos Concentrate/FMP/SSP)
- Production Capacity (Raw Material/Process)
- Preparation of Technical Information (TSP/DAP/NP)
- Techno-Economic Evaluation of Product Alternatives
- Site Selection, Raw Material/Product Transport and Utilities Supply

S/W-5 Basic Plan and Conceptional Design (Phos Concentrate/FMP/SSP)

- Design Basis
- Facility Capacity (Raw Material/Process/Market)
- Facility Design
- Flow Sheet
- General Plot Plan
- Procurement, Transport and Erection
- Construction Schedule
- Commercial Production Schedule
- Organization and Training

S/W-6 Construction Cost Estimate (Phos Concentrate/FMP/SSP)

- Process Plant/Utility/Off-site Facility
- Project Infrasture
- Sparepparts, Chemicals, Electrode, Furnace Brick

A/W-9 License/Engineering/Supervisor/Consultant/Ocean Transport/Custom/Tax/Inland Transport

- Financing and Disbursement
- Foreign and Zambian Currency Portions

S/W-7 Financial Analysis (Phos Concentrate/FMP/SSP plus Integrated Projects)

- Total Financing Required (Fixed/Working Capital/Interest during Construction/Disbursement)
- Financing Plan
- Production Cost Statements
- Income Statements
- Fund Flow Statements
- Profitability and Financial Indicators
- Financial Internal Rate of Return by DCF
- Sensitivity Analysis (Investment Cost/Raw Material Cost/Product Price/Interest Rate/Escalation

S/W-8 Economic and Social Evaluation (Phos Concentrate/FMP/SSP plus Integration Project)

- Economic Pricing
- Economic Internal Rate of Return by DCF
- Foreign Currency Saving/Import Substitution
- Creation of Employment Opportunity
- Industrialization/Technology Transfer
- Export Promotion/Import Substitution of Agriculture Products
- Stable and Low Cost Supply of Phosphate Fertilizer

S/W-9 Study Conclusion and Recommendation

- Study Summary
- Project Outlines
- Evaluation (Raw Material/Alternatives/ROI/Cost/Site/Product Marketability/Capacity)
- Premises for Project Implementation
- Recommendation for Marketing and Distribution
- Overall Evaluation (Phos Concentrate/FMP/SSP)
- Review and Recommendation of Pre-F/S Report for Phosphate Development in Zambia - 1985 by JICA
- Conclusion and Recommendation

A/W-6 Presentation and Discussi

- Comparison and Selection of Scheme (FMP or SSP)
- Demand and Pricing Projecti
- Basic Plan and Conceptual D
- Financial Analysis, Economi
- Recommendation on Marketing
- Recommendation on Phosphate Concentration Plant Project
- Confirmation of Comments of
- Preparation of Minutes of M
- Preparation of Final Report

Notes:
S/W: Scope of Work: INDECO
A/W: Additional Work by Cou

Project Cost Estimate Date: Jan
Foreign Exchange Rate : ZK
Product Alternatives : FM
SS

Step 2: Field Work in Zambia

Step 3: Home Office Work in Japan

Step 4: Presentation and of Draft Final Re

INDECO Ltd., Lus
(Counterpart Agen

Figure I-2 FEASIBILITY STUDY COMPONENTS AND FLOW

- The Feasibility Study on the Establishment of a Fused Magnesium Phosphate Fertilizer Plant in the Republic of Zambia -

1986/1987

Study Team,
Japan International Cooperation Agency
Tokyo, Japan
and
INDECO Ltd., Lusaka, Republic of Zambia
(Counterpart Agency and Coordinating Body)

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Japan)
Zambia
, and others

A/W-4 Summary of Field Study by Progress Report Presentation

- Summary of Study Results
- Confirmation of Scope of Home Office Work in Japan
- Representative Sample
- Raw Material/Process/Product Mix/Project/Capacity/Pricing
- Product Mix Selection Criteria
- Marketability of FMP/SSP
- Basis of Financial/Economic Analysis
- Confirmation of Comments of Counterpart Agency
- Preparation of Minutes of Meeting

S/W-3-6 Raw Material Analysis and Production Tests (Phos Concentrate/FMP/SSP)

- Raw Material Analysis (Chem/Mineralogy)
- Phos Concentration (Small Scale/Batch Wise)
- Production Tests (FMP/SSP: Small Scale/Batch Wise)
- Product Evaluation (Official Method: Zambia/USA/Japan/Europe)
- Product Physical Property
- Product Mix Comparative Evaluation (Raw Material/Process/Cost/Marketability)
- Presentation of Production Test Samples (Phos Concentrate/FMP/SSP)

A/W-5 Optimization Study of Product Alternatives

- Product Alternatives (Phos Concentrate/FMP/SSP)
- Production Capacity (Raw Material/Process)
- Preparation of Technical Information (TSP/DAP/NP)
- Techno-Economic Evaluation of Product Alternatives
- Site Selection, Raw Material/Product Transport and Utilities Supply

S/W-5 Basic Plan and Conceptional Design (Phos Concentrate/FMP/SSP)

- Design Basis
- Facility Capacity (Raw Material/Process/Market)
- Facility Design
- Flow Sheet
- General Plot Plan
- Procurement, Transport and Erection
- Construction Schedule
- Commercial Production Schedule
- Organization and Training

S/W-6 Construction Cost Estimate (Phos Concentrate/FMP/SSP)

- Process Plant/Utility/Off-site Facility
- Project Infrasture
- Spareparts, Chemicals, Electrode, Furnace Brick

A/W-9 License/Engineering/Supervisor/Consultant/Ocean Transport/Custom/Tax/Inland Transport

- Financing and Disbursement
- Foreign and Zambian Currency Portions

S/W-7 Financial Analysis (Phos Concentrate/FMP/SSP plus Integrated Projects)

- Total Financing Required (Fixed/Working Capital/Interest during Construction/Disbursement)
- Financing Plan
- Production Cost Statements
- Income Statements
- Fund Flow Statements
- Profitability and Financial Indicators
- Financial Internal Rate of Return by DCF
- Sensitivity Analysis (Investment Cost/Raw Material Cost/Product Price/Interest Rate/Escalation

S/W-8 Economic and Social Evaluation (Phos Concentrate/FMP/SSP plus Integration Project)

- Economic Pricing
- Economic Internal Rate of Return by DCF
- Foreign Currency Saving/Import Substitution
- Creation of Employment Opportunity
- Industrialization/Technology Transfer
- Export Promotion/Import Substitution of Agriculture Products
- Stable and Low Cost Supply of Phosphate Fertilizer

S/W-9 Study Conclusion and Recommendation

- Study Summary
- Project Outlines
- Evaluation (Raw Material/Alternatives/ROI/Cost/Site/Product Marketability/Capacity)
- Premises for Project Implementation
- Recommendation for Marketing and Distribution
- Overall Evaluation (Phos Concentrate/FMP/SSP)
- Review and Recommendation of Pre-F/S Report for Phosphate Development in Zambia - 1985 by JICA
- Conclusion and Recommendation

A/W-6 Presentation and Discussion of Draft Fianl Report

- Comparison and Selection of the Optimized Project Scheme (FMP or SSP)
- Demand and Pricing Projection
- Basic Plan and Conceptual Design
- Financial Analysis, Economic and Social Evaluation
- Recommendation on Marketing and Distribution
- Recommendation on Phosphate Mining and Concentration Plant Project
- Confirmation of Comments of Counterpart Agency
- Preparation of Minutes of Meeting
- Preparation of Final Report

Notes:
S/W: Scope of Work: INDECO Ltd/JICA-August 19, 1986
A/W: Additional Work by Consultant Team

Project Cost Estimate Date: January , 1987
Foreign Exchange Rate : ZK8.00/US$ (Fixed) - 1987
Product Alternatives : FMP = Fused Magnesium Phosphate
SSP = Single Super Phosphate

Field Work in Zambia | Step 3: Home Office Work in Japan | Step 4: Presentation and Discussion of Draft Final Report in Zambia

PART II
MARKET ASPECTS

PART II MARKET ASPECTS

Chapter 1 AGRICULTURE AND FERTILIZER CONSUMPTION, SUPPLY AND DISTRIBUTION IN ZAMBIA

1.1 Agricultural Sector in Zambia

(1) Agriculture in Zambian Economy

The Zambian economy has largely relied on mining industry, of which copper mining is the major industry. Until 1974, when the copper mining was prosperous, the earning from the copper export accounted for around 95% of total export earning of the country, the contribution of the industry to GDP exceeded 30%, and further, that of government revenue also exceeded 50%.

In contrast to this, importance of agricultural sector is not necessarily high statistically. The agricultural production has developed to supply the food to the workers in copper mining, and the rate of contribution to GDP by the agricultural sector has increased slightly in recent years. However, this is not the result of development of agricultural production, but the result of relative decline in the mining sector caused by stagnation of the industry due to unfavorable international prices of copper as well as difficulty in import of supply and equipments (Table II-1). The employment by the agricultural sector has increased in the recent years as shown in Table II-2, but still it accounts only for less than 10% of total employment.

The agricultural sector in Zambia consists of commercial farming sub-sector and non-commercial (subsistence) farming sub-sector. The situation of agricultural sector in the above statistics represents the commercial sub-sector alone. The reliable statistics on the subsistent farming sub-sector is not available. According to the estimate based on the survey conducted by the CSO, the maize cultivated area by this sub-sector is more than that of the commercial farming sub-sector (Tables II-3 and II-4). There is no reliable data again on the population in this sub-sector. The rural population being 68.1% (or 2,987 thousand) of total population of 4,386

thousand in 1971, and 50.0% (or 3,400 thousand) of total 6,800 thousand in 1985. Since the population in the rural area consists mostly of farmers and agricultural workers, the population absorbed in this sub-sector is estimated large.

Note: The definition of commercial sub-sector (excluding that of livestock industry) in the statistics is as follows;

1) Those farmers who sold more than 150 bags (90kg/bag) of maize to NAMBORAD or Cooperative Union in a year.

2) Tobacco growers who are registered in Tobacco Board of Zambia.

(2) Characteristics of Zambian Agriculture in View of Farm Management

The agricultural sector in Zambia consists of commercial farming sub-sector and non-commercial farming sub-sector as described in the foregoing section (Table II-5). The commercial farming sub-sector was originated historically from the large scale farms by the European farmers who settled in the land alongside the railway in Central and Southern provinces. They generally own more than 2,000ha of land as shown in Table II-6, and mostly more than 5,000ha (the farmers in this class are referred to the class of farmers with more than 800ha in the statistics in Tables II-6 and II-7). They use large agricultural machineries, employ agricultural workers, and sometimes own the large scale irrigation facilities. The farmers in this class are quite price conscious. When the market price of the agricultural product is unfavorable, they reduce the cultivated area down to the level which can be operated by the permanent staffs alone. However, once the market situation is improved, they increase the cultivated area employing the temporary workers. At present, since the price of maize in the domestic market has fixed at low level, they are inclined to shift to the export grade tobacco and coffee cultivation to gain the revenue in foreign currency.

There are medium scale commercial farmers next to the above stated large scale commercial farmers. The size of their own land is distributed widely from 80ha up to 800ha. The upper class of this medium scale farmers resembles to the large scale farmers in the management practice.

However, the lower class is the farmers who have been developed from the subsistence farmers. Many of the upper level farmers in this class with more than 100ha of own land, have been originated from the farmers who immigrated from Zimbabwe, and there are also many farmers who came into the sector from outside of agricultural sector investing their capital obtained from out of the sector. Most of the farmers in this class own the agricultural machineries like tractor, and sometimes employ the agricultural workers. However, because of limitation of the financial fund, they can not afford to buy the sufficient agricultural inputs and fuels, and therefore, they cultivate only a part of their own land. Especially in the case of maize, for which cultivation fertilizer is essential, they are increasingly growing it as a rotation crop with other crops such as cotton, sunflower, and green manure crops, etc. to maintain the fertility of the soil. The difficulty in obtaining the agricultural inputs in the recent years further spurs on this tendency.

There are small scale farmers in the commercial farming sector other than the aboves. They developed themselves from the subsistence farmers by producing the surplus products to be marketed by improving the productivity. In Zambia the land is available abundantly, and the limiting factor for the expansion of agricultural production is the availability of labor forces. If the ratio of family members at working ages in the family increases, and they can produce the surplus over the family requirement, then they can market it to obtain the cash. With the cash they may buy oxen, resulting in the improvement in the productivity compared with the former farming with hoes and plows only. This will result in the further increase in the production and continuing marketable surplus. Thus, the subsistence farmers could develop themselves from the subsistence farmers to the partly commercial farmers. The further increase in the marketable production could result in the purchase of tractor, which enable them to expand the cultivation land.

The subsistence farmers in the suburbs of large cities, or alongside the main roads are easy to access the market, and therefore, they can sell the surplus to the market. In addition, they have chances to learn the progressed cultivation practice from the commercial farmers, and they try to increase their production following such practice. However, by contrast, the farmers in the area remote to the markets and with no

contact from the buyers, will remain as the subsistence farmers because of difficulty to market their products without transportation facilities, even if they have the surplus products.

(3) Agricultural Production in Zambia

Table II-8 shows the change in the agricultural production in Zambia. The available statistics on the agricultural production is limited to that of commercial farming sector only, as explained already. At the same time, the long term data on agriculture does not coincide with the data of the recent years.

Zambian agriculture lacks the irrigation facilities except for the sugarcane estate in Southern province and a part of large scale commercial farms. The production performance has been affected influences greatly from the weather condition in the year (for the natural condition relating to the agricultural production, see Annex II-2).

Maize is the main foodstaff in Zambia, and the cultivation area of Maize is the largest among the other crops. The cultivation area of maize has increased in the long term. Especially, the maize area in the commercial farming sector has increased up to 1977, with expansion of maize area in the commercial sector together with development of subsistence farms into the commercial farms. The average yield level of maize showed decrease in 1977, and after that the yield improvement has been stagnated. This is due to the fact that the development of subsistence farmers to commercial farmers has increasingly observed in this period, resulting in the decline in the average yield level with introduction of low yield farms into the sector. At the same time, the continuing drought in Southern provice also lowered the average yield level.

Despite the fact that maize is not necessarily the suitable crop for Zambia in view of natural condition in this country compared with such crops as sorgham, millet, and cassava, etc., the cultivation area of maize has increased, especially in Eastern and Northern provinces. However, on the other hand, the maize production in Southern province, which has been one of the leading production areas, decreased due to the continuing drought, and as a result, the production in total Zambia has stagnated.

Sunflower is the second major crop in terms of cropped area, and the area tends to increase further. The expansion of cropped area of sunflower is desirable for the country from the standpoint of import substitution of cooking oil. If the number of regional oil extraction facilities is increased, the cropped area will increase. The sunflower has grown extensively by the small scale farmers mainly in Central, Eastern, and Southern provinces, when they can not afford to buy the agricultural inputs and/or seeds for maize.

Soybean has been grown by the large scale commercial farmers as a off-season crop of wheat, on one hand, and grown under the maize-cotton-soybean rotation cropping guided by LINTCO by the small scale farmers, on the other hand. The government is expecting the expansion of production in view of increase in the cooking oil extraction, and the cultivated area of soybean will continue to increase in the future.

The cropped area of groundnuts has increased as a cash crop for the small scale farmers, and it has been grown mainly in Eastern, Southern, and Central provinces. The groundnut is sold for confectionary, rather than for oil extraction. It is purchased mainly by local buyers instead to be sold in the official market, because the puchase price in the former is higher. However, since the planting season of the groundnuts overlaps with that of maize, the shortage of labor has limited the expansion of cropped area.

Wheat is grown only by the large scale commercial farmers who have their own irrigation facilities, due to the fact that the wheat is hard to be grown in the rainfed area, and that harvester or labor for harvest is necessary in time. The cultivated area of this crop will increase gradually among the large scale commercial farmers. (The statistics system on the wheat production is not established yet at present, and only the data on marketed production is available. According to the data in "Economic Review and Annual Plan, 1986" (NCDP), the cultivation area of wheat is estimated at around 2,800ha in 1985.)

Cropped area of cotton has increased steadily since the establishment of LINTCO in 1978. The small scale commercial farmers have played an important role in its growing, and the major cropping area is distributed in Central and Southern provinces. Tobacco growing is declining due to

disincentive for the small scale farmers caused by the low yield together with high production costs. However, the high quality export grade tobacco is continued to be grown by the large scale commercial farmers. Coffee is still small in production in this country, but paid attention as a prospective export crop. Fifty percent of the coffee is produced by the large scale commercial farmers, whereas 40% by the national projects.

Sorgham, millet and cassava have been grown solely for home consumption except for the small portion of millet used for brewing. Thus, there is no possibility for the farmers to expand its production more than they require for their own consumption. Beans other than soybean has grown not only for own consumption, but as a cash crop also.

Zambia exported small amount of maize in the past, but in the recent years, it has imported maize, rice and wheat in large amount as shown in Table II-9.

(4) The Target of Agricultural Production

According to the Annual Plan, 1986, the followings are the mid-term targets of agricultural production:

a) Achieve the self-sufficiency of maize, cassava and sorgham

b) Increase the production of beef, cotton, tobacco and livestocks for export

c) Increase the production of import substitution crops

1.2 Consumption of Fertilizer in Zambia

(1) Trend and Characteristics of Fertilizer Consumption

The consumption of fertilizer in Zambia had increased year by year until 1977 as shown in Table II-10. However, after that, the consumption level fluctuated year to year, and the highest consumption level recorded after 1980 was 218,800 tons (in nutrient equivalents, 57,800 tons for N, 21,700 tons for P_2O_5 and 8,000 tons for K_2O respectively). The cause of such

fluctuation is not clear, but the fluctuation of cultivation area in accordance with the market situation of agricultural products, and the drought, are estimated the two major reasons for this.

One of the characteristics of fertilizer consumption pattern in Zambia is that most fertilizer is consumed as compound fertilizer. It is recommended to use 4 bags of compound fertilizer as basal dressing and 4 bags of urea as topdressing in this country. This recommendation has been widely diffused among the farmers from the large scale commercial farmers to small scale farmers.

(2) Consumption of Fertilizer by Crop

Most fertilizer has been used on maize. Large and medium-scale farmers apply fertilizer on maize almost without exception. In the case of small-scale commercial farmers, they apply fertilizer on maize in general, but sometimes do not apply it because of lack of money or credit to buy fertilizer. However, subsistence farmers do not apply fertilizer at all because of lack of purchasing power, although they desire to apply fertilizer since they know the effectiveness of fertilizer for improving yields, having seen what large scale farmers achieve.

With respect to the crops other than maize, Virginia tobacco, which is grown by the large scale farmers, has received fertilizer. In the case of vegetables, organic fertilizer has been used with chemical fertilizer partly. For other crops, fertilizer has not been applied so far. The emphasis of practice is put on the maintenance of fertility of land by rotation cropping both in the practice of large scale farmers and the recommendation by DOA and LINTCO for small scale farmers. Therefore, the fertilizer is applied only on maize, which is one of the rotation crops, and no fertilizer is applied on other crops. In the case of large/medium scale farmers, they grow one or two seasons of such legume crops as soybean, groundnuts and sunhemp (crotalaria) after maize, followed by the next cropping of maize. On the other hand, the LINTCO recommends the rotation of maize-cotton-soybean with fertilizer only on maize. The cotton is grown on the residual effect of the fertilizer applied on maize, in this case.

There are 6 grades of compound fertilizers in the market, and three of which, "X", "D", and "R", are used mostly on maize. A part of these

compound fertilizer is also used on wheat, but the amount is negligeble. Among these grades, "D" is the standard grade designed for basal dressing to be applied before planting. The grade "X" is also classified as a basal dressing grade in view of application time, but in reality, it is designed for the small scale farmers who plant crops upon start of rainy season with applying fertilizer after planting. The grade "R" is for Southern province, where potassium application is not required.

The compounds "C", "A" and "V" are for tobacco and vegetables, and mainly "C" and "A" are used on tobacco, while "C" on vegetables. The grade "A" is not used in the recent years.

For topdressing, urea is commonly used, but domestically produced ammonium nitrate is also used for this purpose.

Despite the above recommendation the farmers have been compelled to use the fertilizer other than recommended one because of limitation in supply of the fertilizers.

1.3 Fertilizer Supply and Distribution in Zambia

(1) Fertilizer Supply

The total balance of fertilizer in Zambia in 1983 through 1986 is shown in Table II-11. Most supply has been imported. NCZ is the sole producer of fertilizer in Zambia, and has the production facilities for ammonia, ammonium nitrate, ammonium sulphate and compound fertilizer. Therefore, a part of nitrogen is supplied by NCZ in ammonium nitrate and compound fertilizer, while the ammonium sulphate is used solely for a raw material of compound fertilizer because of limitation of the production facility. The remaining requirement of nitrogen is imported either as end-product compound fertilizer and urea, or as raw material DAP for NCZ. All the phosphate and potassium requirement is imported in the form of DAP, TSP, SOP and compound fertilizers. Of which DAP, TSP, and SOP is imported by the NCZ for raw materials of compound fertilizer.

(2) Fertilizer Distribution

Fertilizer distribution has been monopolized by NAMBOARD; except for the raw material fertilizers imported by the NCZ, all the fertilizers have been imported by the NAMBOARD, and all the fertilizers produced by the NCZ have been distributed by the NAMBOARD. There were two distribution routes at the provincial level, namely, the route in which fertilizer is sold through the outlets of NAMBOARD, and the route in which fertilizer is sold to provincial Cooperative Union and then sold to the farmers (Figure II-1).

In 1986, the goverment decided to liberalize fertilizer distribution by abolishing the monopoly of NAMBOARD. As a result, those who wish to handle fertilizer import and/or distribution became able to handle it in principle. The most depot facilities of NAMBOARD were transferred to Coopertive Unions, and the Cooperative Unions was expected to be in a leading position in the fertilizer distribution. However, because of insufficient provision with respect to fund and facilities (especially transportation facilities) together with existence of subsidies (or official prices), liberalization was not materialized and the NAMBOARD handled the distribution as in the past.

(3) Fertilizer Price and Subsidy on Fertilizer

The price of fertilizer has been fixed at two levels by the government, namely, the sales price of NCZ to NAMBOARD and the price at outlets. The sales price of NCZ to NAMBOARD has been set lower than the production cost of NCZ in recent years, and the difference is to be compensated by the government. This difference is called the producer subsidy.

The sales prices at all outlets are the same regardless of the location of the outlets. The difference between the set price and the cost delivered to the outlet which varies depending on the distance from the origin, is called transportation subsidy. The delivered cost at the outlet including the agent fee is higher than the official price at the outlet. This difference is also referred as the transportation subsidy.

Table II-12 compares the landed cost of imported fertilizer by NAMBOARD, official purchase price from NCZ, and official sales price by NAMBOARD.

The total subsidy on fertilizer in 1971, when the subsidy started, was ZK3 million, but it increased conspicuously to ZK36 million and ZK50.3 million in 1975 and 1982 respectively. The fer-tilizer was subsidized in this period to control the sales price of maize to the consumers at low level, and promote the fertilizer use. However, the subsidy was reduced since 1983 with recommendation of IMF. The total amount of subsidy paid was decreased as a result, to ZK19.9 million in 1983 and further to ZK10.1 million in 1984. Thus, the price of fertilizer has increased significantly year by year. Furthermore, because of increase in the prices of imported fertilizer and raw materials in terms of Kwacha, caused by decline in the exchange rate of Kwacha to U.S. dollar, on one hand, and the official price reflecting the government intention to keep the prices low, on the other hand, the difference between the actual cost of fertilizer and the official sales price has increased.

(4) Physical Distribution of Fertilizer

The domestically produced fertilizer is purchased by NAMBOARD at ex-factory from NCZ, and transported to the major depots either by road or rail. The fertilizer is further transported to the outlet depot, and sold to the farmers. The transportation from the outlet depots to the farm gate is made by the farmers. The large scale farmers use truck for the transportation, whereas the medium or small scale farmers use either tractors, oxen-driven cart, cart, or bicycle. Farmers hire a pick-up truck jointly in some cases.

Imported fertilizers are unloaded mainly at Dar-es-Salaam in Tanzania, bagged there and transported directly to main depots by rail. The physical distribution route after that is shown in Figure II-2. Lobito port in Angola and Maputo port in Mozambique have been also used for this purpose. The route directly from Rep. of South Africa by road has been often used in recent years due to port congestion at Dar-es-Salaam.

Chapter 2 MARKETABILITY OF FMP AND SSP IN ZAMBIA

2.1 FMP

(1) Marketability of FMP

The FMP is a phosphate fertilizer, and at the same time a material which is expected to have additional effects from the containing magnesium, calcium, and silicic acid. The marketability of FMP is examined in the forthcoming section taking into account the situation of Zambian fertilizer market.

1) Marketability of FMP as a phosphate fertilizer

All the phosphate fertilizer used in Zambia contains water-soluble phosphate, while the FMP contains citric-soluble phosphate only. So far, no well organized field experiments have been conducted in Zambia regarding the effectiveness of citric-soluble phosphate on crop yield. According to a limited number of FMP applications in Zambia, the effectiveness of FMP is understood to be equal to that of water-soluble phosphate fertilizers.

One percent of citric-soluble phosphate is equivalent to that of water-soluble phosphate in its effectiveness in general, in the acidic soil area widely distributed in Zambia. (For further detail, see Annex II-3.) The area of Zambia where the effectiveness of FMP is expected covers most except for limited areas as shown in Figure II-3.

Nevertheless, the absorption of citric-soluble phosphate by plant requires slightly longer time than that of water-soluble phosphate, and therefore, if all the phosphate requirement is supplied in citric-soluble phosphate, the supply of phosphate at the initial stage of plant growth could be insufficient. Thus, in the case of application of FMP as the phosphate fertilizer, it should be applied earlier than that of water-soluble phosphate, before the planting, or at least 20% of total phosphate requirement should be applied in water-soluble form if it is applied immediately before planting.

According to the prevailing fertilizer application practice, the phosphate fertilizer is applied as basal dressing, and in compound fertilizer. Therefore, the introduction of FMP will not be easy in Zambian market without modifying the present fertilizer application practice. At present, there is an opinion among the leaders in agricultural sector to promote the use of domestically produced fertilizer, modifying the fertilizer application practice in view of financial difficulty of the country. With such support for the introduction of FMP as a domestically produced fertilizer, the marketability of FMP may be expected despite the above described difficulties in its introduction.

2) Marketability of FMP based on the additional effects from the accessory contents

The FMP contains magnesium, calcium, and soluble silicic acid, and the compound effects are expected from these accessory contents in addition to the above. One is the effect as a supply source of plant nutrients of these contents, and another is the effect as a soil improvement material on the soil acidity.

However, the former effect was not taken into consideration in this study, because of lack of field experiments to evaluate it.

The FMP is suitable for amendment of soil acidity in general, and this point is well recognized in such areas as volcanic ash soil area of Japan, and tropical heavy rainfall area of Brazil. The alkalinity of FMP, which contains 30% of CaO and 15% of MgO, is 51, whereas lime in general with 50% of CaO is 50 and Lusaka lime with 50% of CaO and 20% of MgO is 78. Therefore, the FMP is required to be applied at the same dosage as that of lime (or 1.5 times that of Lusaka lime) to obtain the acidity amendment effect. The recommended dosage of lime on maize in Zambia is shown below. The soil on which a large volume of lime application is recommended, is distributed as shown in Figure II-3.

Recommended Dosage of Lime on Maize, in Zambia

	Recommended dosage (kg/ha)
Sandy	500-1,000
Sandy loam	1,000-1,500
Sandy cray	1,500-2,000

Note: Based on lime with 50 alkalinity

Source: Mount Makulu Central Research Station

The potential demand for the materials to amend soil acidity icluding lime is very large, but actual use of these materials is limited to a part of large scale commercial farmers. The shipment volume of Lusaka lime in the past is shown as below.

Shipment Volume of Lusaka Lime

	tons
1980	5,003
1981	5,294
1982	9,319
1983/84	3,815
1984/85	4,014
1985/86	2,873

Note: Lusaka lime only. Kabwe lime and Ndola lime, etc. are the other sources of lime in Zambia. Lusaka lime is most effective on acidity amendment among others, and most popular in Zambia.

Source: Crushed Stone Sales, Ltd.

The reason why the actual consumption is very low compared with the potential demand may be attributable to the fact that cost of lime application is high in view of maize price. Even the large scale commercial farmers have applied it only on the attractive cash crops like tobacco for export and maize. The medium scale commercial farmers well

recognize the necessity of lime application on their farm, but they cannot afford to buy it. At the same time, the fact that large/medium commercial farmers have cultivated only a part of their own land, and therefore, they can practice the crop rotation with legume crops to maintain the soil fertility and improve acidity, may be another factor for low lime consumption.

The CaO and MgO contained in the FMP is effective to amend soil acidity, as stated in the foregoing section. However, in order to expect such effect, the large volume of FMP is necessary to be applied. There is no data available with respect to the adequate dosage for FMP to obtain such effect, but according to the data on the similar soil to that of Zambia in other country (Cerrad area in Brazil), 250kg P2O5/ha (or 1,250kg/ha of FMP) is estimated to be required in the case of Zambia (see Annex II-3). The present recommended dosage of phosphate fertilizer is 20-40kg P2O5/ha at most in Zambia, and it is hard to expect the soil amendment effect from that level of FMP application. Further, the accumulative effect on acidity amendment is also doubtful from such level of FMP application. Thus, it may be concluded that the effect of contained CaO and MgO as acidity amendment material is hard to evaluate in addition to that of contained phosphate, without confirming the effectiveness through the field test on Zambian soil.

(2) Suggestion on Promotion of Use of FMP and its Distribution

1) Product type of FMP

The FMP cannot be formulated into compound fertilizer, and so, it is used as a straight fertilizer. The FMP is applied as basal dressing, and therefore, it is applied either using machine or manually with mixing with such basal dressing fertilizer as nitrogen, water-soluble phosphate, and potassium fertilizers, just before application.

2) Suggestion on promotion of use of FMP and its distribution

The marketability of FMP largely depends on the support from the leaders in the agricultural sector, as described in the foregoing section. The support is necessary in the following areas, but not limited to;

a) The fertilizer recommendation should be modified to include the use of FMP (see Annex II-4).

b) The grade of presently used compound fertilizers "D", "X", and "R" should be modified to meet the application practice using FMP (see Annex II-4).

c) Promotion campaign should be carried out at the time of FMP introduction to the market.

The phosphate content is regulated to be indicated in terms of content of water-soluble phosphate in Zambia. Since the FMP contains citric-soluble phosphate only, the fertilizer regulation should be modified so that the FMP contents can be shown in citric soluble phosphate.

There is no data showing the effectiveness of phosphate derived from the FMP, based on the field tests in Zambia. The above examination of FMP's effectiveness was based on the tests on the soils in other countries similar to the soils in Zambia. However, in order to assure the effectiveness and utilize the results for the purpose of sales promotion, the field tests on Zambian soil is indispensable.

The promotion of use of FMP is quite recommendable in view of maintaining the soil fertility as well as amendment of soil acidity.

2.2 SSP

(1) Marketability of SSP

The phosphate contained in SSP is mostly water-soluble, and the effectiveness of the contained phosphate is equivalent to that of other phosphate fertilizers now used in Zambia. Therefore, marketability of SSP in view of effectiveness is not in question at all.

In addition, the effectiveness sulphur application is well recognized in Zambia, and the SSP is advantageous from this point of view.

SSP can be used either as a straight fertilizer or a raw material of compound fertilizer. If it is used as a raw material of compound fertilizer, the grade of compound fertilizer is lowered, resulting in the necessity to modify the application practice. If it is used as a straight fertilizer, the application practice should be modified as in the case of FMP introduction. Further SSP has disadvantage in that phosphate content is lower than that of other phosphate fertilizers such as DAP and TSP. So, the intensive support by the leaders in the agricultural sector is essential to introduce SSP to the market.

(2) Suggestion on Promotion of SSP and its Distribution

1) Type of SSP

If the SSP is used as a raw material of compound fertilizer, the grade of it will be lowered, resulting in the higher cost for transportation. In order to keep the burden of farmers at the same level as that of present application practice, the price of SSP obtained by the compound fertilizer producer has to be lowered than the price of straight fertilizer sold to the farmers. Thus, in order not to increase the farmers' burden by introduction of SSP and to increase the sales price of SSP, SSP is necessary to be marketed as a straight fertilizer.

The supply ability of phosphate rock from the domestic source is limited to only 50% of the highest annual consumption level attained in the past (approximately 20,000 P_2O_5 tons/year). Thus, when the SSP is used as a raw material of compound fertilizer, a large part (around 2/3 of requirement including future increase in the demand) has to be met by the imported phosphate such as DAP and TSP. The required volume of the SSP varies year by year depending on the level of domestic consumption. In order to cope with such inconvenience, the volume of input of SSP should be underestimated. This will result in lowering the demand and making it unstable.

If the SSP is used as a straight fertilizer, as in the case of FMP introduction, the present application practice is necessary to be modified. Thus, though SSP can be used either as a straight fertilizer or a raw material for compound fertilizer, promotion measure is required for the successful introduction of the SSP.

2) Suggestion on promotion of SSP use and its distribution

As in the case of introduction of FMP, the sufficient support by the leaders in the agricultural sector is necessary in the introduction of SSP with respect to the following points:

a) The fertilizer recommendation should be revised to be applicable for SSP (see Annex II-4).

b) The N:P:K ratio of presently used compound fertilizer should be revised accordingly (see Annex II-4).

c) The promotion campaign should be carried out to introduce the SSP.

In addition, the granule size distribution of the SSP should be adjusted to that of compound fertilizer to avoid segregation, in case the SSP is used as a straight fertilizer, since it has to be mixed together before application.

(The additional facility is required for the granulation of the SSP to be used as a straight fertilizer.)

Chapter 3 PROJECTION OF SALES PRICES OF FMP/SSP

3.1 Condition and Assumptions of Sales Price Projection

The sales price to be projected in this chapter is the price to be used in the financial evaluation of this project. Therefore, the price projection is required to reflect the price formulation mechanism in the market.

(1) Assumptions in View of Characteristics of the Market

1) The distribution and market price of fertilizer is controlled by the government. The import and distribution are monopolized by the state company, NAMBOARD, and the market price is set by the government. The basic policy of the government is to gradually reduce governmental control. An effort to abolish the distribution monopoly was made in 1986 as the first step of this liberalization. In this price projection, the market price is assumed to be formulated on the basis of competition among the products from various sources as well as suppliers, with decontrol in setting the price. However, the liberalization of distribution system, in other words formulation of competition in the market among a number of distributors, will be rather hard to be expected in a short period of time, since the potential distributors are very limited in number, and the foreign exchange is not sufficient to allow free import. Nevertheless, the liberalization is expected to proceed to the extent that the distributor(s) on one hand, will import and distribute a various kind of fertilizers based on the needs of farmers and sell it at the price formulated in the market, and consumers (farmers) on the other hand, will choose the fertilizer on the basis of their needs and economics.

2) At present, the application practice of using compound fertilizer for the basal dressing and urea for topdressing has been well established under the leadership of leading organizations in the agricultural sector. The price of fertilizer has been fixed so that the use of compound fertilizer costs almost equivalent to that of combination of some straight fertilizers; generally, the price of compound fertilizer is expensive compared with the cost of combination of straight fertilizers reflecting the convenience of use of the compound fertilizer (Table II-13). If the import of fertilizer is liberalized and the cost of use of combined straight fertilizer becomes much attractive

than that of compound fertilizer, there might be a conversion from use of compound fertilizer. If such is the case, the conversion will be taken place by the large scale commercial farmers at the initial stage, and then be diffused to other farmers, since the large scale commercial farmers are very much price consciuos.

However, if the difference in the required cost between the compound fertilizer and combination of straight fertilizer is small, the present application practice will be preferred due to convenience in handling and familiarity in the practice.

3) The FMP is regarded not only as a phosphate fertilizer but also as a material which has the additional effects by the containing CaO and MgO, in general. However, in the case of Zambian market, it is found that the value for the acidity amendment material is hard to be assessed in this study due to the fact that the field tests with respect to the effectiveness of FMP on the Zambian soil is not available to evaluate the additional effect of CaO and MgO.

4) The application of sulfur is indispensable in Zambia. When the SSP is applied, not only the phosphate but the sulfur is also applied. Therefore, the price of SSP should include the value of sulfur in addition to that of contained phosphate. The value of sulphur in the SSP can be assessed by calculating the required additional application cost of sulfur without using the SSP.

(2) Assumptions Commonly Applied to Project Costs Estimate

Among the assumptions applied to project cost estimate, followings are used commonly in this price projection:

a) The price is expressed at the price in mid-1991.

b) The exchange rate between Kwacha and US dollar is assumed at US$1.00=ZK8.00 at the beginning of 1987, and fixed onwards for the calculation purpose.

c) The general price increase rate is assumed to be 3% p.a. regardless of domestic goods or international goods in terms of US dollar.

(3) Other Assumptions

1) In the projection of international market prices of fertilizer, the price of crude oil, which is one of the factor affecting influences on the price formulation of the fertilizer, is assumed as follows:

(Unit: US$/bbl at 1985 price)

	Arabian Light (f.o.b. origin)
1987	16.5
1988	21.0
1989	21.0
1990	21.2
1991	21.7
1996	24.8

Source: Crude oil price forecast by the Institute of Energy Economics, Tokyo, Japan (1985)

2) The international market price of fertilizer is the average of the projected prices in 6 years from 1991 through 1996, which are expressed in 1991 price (for the detail, see Annex II-5).

3.2 Projection of Sales Price of FMP/SSP

(1) Farmers Practice in Selecting the Fertilizer under Present Price System

Generally speaking, consumers (farmers) will choose a convenient and lowest cost fertilizer among the various alternatives, if such alternatives are available. There is no alternatives in Zambia at present but compound fertilizer as basal dressing and urea as topdressing, with respect to the fertilizer. Even if the alternatives are available, the present practice pattern is the best in view of convenience and lowest cost under the present pricing (Table II-13).

(2) Sales Price of FMP/SSP to Introduce It to the Market Where Use of Compound Fertilizer as Basal Dressing and Urea as Topdressing is Practiced

There are two alternatives to meet the application requirement under the assumed liberalized distribution system. One is the combination of straight

fertilizers and another is use of compound fertilizer as at present. The projected burden by farmers was compared for these cases on the basis of projected international market prices. The result showed that the cost of use of compound fertilizer is 13% higher than that of combination of straight fertilizer (Cases 1.1 and 1.2, Table II-14). Here, the market price is assumed to be formulated on the basis of imported cost regardless of domestic or imported products. However, this combination of compound fertilizer is calculated on the basis of theoretical dosage neglecting the actual required number of bags for each farmer; the farmers will buy the fertilizer based on their rough estimate of required number of bags, and therefore, the actually purchased number of bags normally exceeds that of the theoretical one. Further, since use of compound fertilizer with topdressing urea is easier in handling and familiar to the farmers, they will prefer to the latter with such small cost difference.

In the case of introduction of FMP/SSP to a market where the use of compound fertilizer is established (Table II-14), there are some non-price disadvantages. Namely, the introduction of FMP/SSP will increase the number of total bags of fertilizer to be used (Table II-15) and moreover, pre-mix of FMP with other fertilizers is necessary in the case of FMP, thereby increasing inconvenience. Thus, the total cost of FMP and other fertilizer (or compound fertilizer using SSP) should be less than that of the present application pattern if use of FMP/SSP is to be accepted (Cases 2.1 and 2.2 against Case 1.2).

If the total burden by farmers for introduction of FMP/SSP (Cases 2.2 and 2.1) is equal to that of present application pattern (Case 1.2), then the projected ex-factory price of FMP is US$110/ton (or ZK880/ton) (Table II-14). In the case of SSP, the ex-factory price of compound fertilizer using SSP (referred to CX-SSP hereafter) is US$235/ton (or ZK1,880/ton), thereby the price of SSP delivered to the compound fertilizer factory is US$80/ton (or ZK640/ton) at most, even with the assumption of no formulation cost other than main raw material costs for the compound fertilizer.

Note: The formulation cost other than main raw material costs of compound "D", which is the representative grade in Zambia at present, is estimated ZK516/ton, with assumption that the formulation cost

accounts for 20% of total manufacturing cost and that all the raw material cost is estimated using import cost (expressed in 1991 price). Since the total contents of NPK in CX-SSP is 10% lower than that of CX "D", the fixed cost per ton of CX-SSP is 10% lower than that of CX "D", if there is an idle capacity of manufacturing compound fertilizer. Even if such is the case, the SSP cannot be priced at the delivered point to the compound fertilizer factory (the formulation cost is ZK464/ton in this case).

If the introduction of FMP/SSP is assumed to be strongly supported by the leaders in the agricultural sector, the price of these products may be accepted in the market at maximum 20% of premium per 1% of P_2O_5 contained. In this case, the price of FMP is US$130/ton (or ZK1,040/ton)(Table II-14), and that of SSP is US$121/ton (or ZK970/ton) without taking into account the formulation cost. The SSP cannot be priced again if the formulation cost of compound fertilizer is subtracted.

(3) Sales Price of FMP/SSP to Introduce It to the Market Where Use of Combination of Straight Fertilizer is Practiced

The potential sales price in the foregoing section was projected on the assumption that the present application practice in which compound fertilizer is used as basal dressing is still applicable. However, if the farmers change their practice of using combination of straight fertilizer by the time of introduction of FMP/SSP, as a result of liberalization of fertilizer distribution, then the farmers' attitude toward the selection of new fertilizer is a little different from the case examined in the foregoing section. In such case, whether the farmers will use the FMP/CX-SSP or not depends on the cost to them of using FMP/CX-SSP in comparison with that of phosphate fertilizer. The price of FMP should be equivalent to or less than that of fertilizer now in use in terms of 1% phosphate content. Thus, the price of FMP may be estimated by the following formula:

(Price of FMP) = (Price of TSP)x20/46

or

(Price of FMP) = [(Price of DAP)-(Price of urea)x18/46]x20/46

In this case, the former is US$102/ton (ZK815/ton) and the latter is US$76/ton (ZK620/ton).

In the case of CX-SSP, the estimated price of SSP is the same as that of compound fertilizer with urea examined in the foregoing section.

If the introduction of FMP/SSP is strongly supported by the leaders in the agricultural sector, the 20% higher prices may be accepted compared with the above projected prices in terms of unit price per content percent. If such is the case, the price of FMP will be US$91-122/ton (ZK744-978/ton).

(4) Projected Prices of FMP/SSP

On the basis of the foregoing examination, the sales price of FMP/SSP is projected as follows:

Projected Potential Sales Prices of FMP/SSP

	Ex-factory Price (US$/ton)
FMP	US$110/ton±20%
SSP	US$97/ton*/

Note: */ Expected maximum price

3.3 Policy Option on Fertilizer Distribution, and its Influences on Sales Prices

In the foregoing section, the price of FMP/SSP was projected on the assumption that the distribution of fertilizer will be liberalized. However, it will take time before a number of distributors will become established in the business, in view of present situation of distribution as described already. At the same time, the liberalization of price formulation is also doubtful since the liberalization of prices must be done together with that of other goods. The possibility to realize the free import is closely related to the policy option of how to deal with domestic production, namely the operation of NCZ. In the following sections, the influence on the projected prices of FMP/SSP of such policy options relating to the fertilizer distribution is examined.

(1) The Case in Which the Price Increase Rate will be Controlled at the Same Rate of General Price Increase (Scenario 1)

This scenario assumes that the prices of all the fertilizers are increased by 3.0% p.a. (the same increase rate as that of general price) from the official price in 1986. In this case, the prices in mid-1991 will be lower than the imported cost of fertilizers (Table II-14) as shown in Table II-16, and it implies that the fertilizers are subsidized at that time.

In this scenario, use of set of fertilizers according to the present application pattern costs 16% higher than that of combination of straight fertilizers. However, with this difference, the farmers will prefer the present application pattern because of its easiness in handling. Assuming the introduction of FMP to such a market, the projected salable price of FMP will be as low as US$80/ton (ZK640/ton), calculated by comparing the cost with that of present application pattern as was the Case 2.2, and shown in Table II-16. This is because the cost of fertilizers to be replaced by the FMP is kept at a lower level than import costs by the official prices (Case 1.1).

The producer of the FMP will be entitled to receive a subsidy, in this case. The rate of ex-depot price to ex-factory price, which represents the subsidy rate, has changed greatly in the past, 48% on the average in the years 1980 through 1982, while it was 80-82% in 1983 through 1985, as shown in Table II-12 in 1.3 of Chapter 1. The rate may vary depending on the policy decision with respect to the extent of protection of domestic producers. The projected sales price of FMP will be about US$110/ton (ZK880/ton), assuming the rate 25%.

The SSP cannot be priced with this scenario again.

(2) The Case in Which the Operation of NCZ is Assumed as the Basis of Policy Option (Scenario 2)

The shortage of foreign exchange in Zambia might remain unchanged in the future if the international copper market stays soft. Since the operation of NCZ results in foreign exchange saving through utilization of domestic resources of nitrogen, there is possibility for the distribution of fertilizer, which competes with that of NCZ, to be restricted to protect the operation of NCZ.

If such is the case, the liberalization will be limited to some extent. However, at what cost level the price is to be set varies depending on such factors as general price change, extent of foreign exchange shortage, direction of agricultural policy, availability of financial funds for fertilizer subsidies, etc. The lowest case among them will be the one in which the fertilizer price is increased at the rate of general price increase, as shown in Scenario 1, and the highest case is the one in which the price is set to cover the cost of domestic production of NCZ for domestic compound fertilizers and the cost of import for imported straight fertilizers. There are various alternatives of price level between the two extreme cases depending on the policy option.

Table II-17 presents the sales price of FMP, projected with the assumption that the formulation cost of compound fertilizer accounts for 15-25% of total production cost. Since the FMP replaces a part of compound fertilizer now used, the higher the price of compound fertilizer, the higher the possible sales price of FMP, with the highest case being US$178/ton (ZK1,424/ton).

Assuming that NCZ continues to operate, the possible sales price of SSP as a raw material of compound fertilizer for the producer of compound fertilizer (NCZ) will be equivalent to, or less than that of other phosphate fertilizer in terms of 1% phosphate content. Table II-18 gives the salable price of SSP, projected by comparing the raw material cost of compound "D" with that of CX-SSP "DS". The highest price under such circumstance is US$142/ton (ZK1,139/ton). (The above estimate is based on the comparison of main raw material costs only, neglecting other production costs. However, the contained NPK grade of CX-SSP is 10% lower than that of compound "D", and therefore, the production of CX-D has disadvantage in transportation cost by 10%. Nevertheless, this point may be disregarded with the assumption of continuance of NCZ operation.)

Chapter 4 PROJECTED MARKET QUANTITY OF FMP/SSP IN ZAMBIA

4.1 Factors Affecting the Demand for Fertilizer

Most fertilizer in Zambia is consumed for maize. In this context, the major factor affecting the demand for fertilizer is change in the cultivation area of maize in commercial farm sector. In the long term, the maize cultivation area increases in accordance with increase in urban population, which results in the increase in maize demand and gives the incentive for maize production. The urban population has increased by 7.35% p.a. in 22 years from 1963 through 1985, while total population increased by 3.08% p.a. The maize production has increased in accordance with the urban population, but the increase rate has been less than the latter, resulting in approximately 10% of import of total requirement during 5 years from 1981 through 1985.

The major factor affecting influences on maize cultivation other than natural factor like drought, is the market price of maize. If the market price of maize is not attractive, the commercial farmers, especially, large and medium scale farmers, decrease their cultiveted area, and as a result, the consumption of fertilizer declines.

Another factor exerting the influence on maize production is lack of supply or purchasing power of agricultural inputs. This is especially observed among the medium and small scale commercial farmers.

Thus, the maize cultivation area does not necessarily increase directly in response to increase in the urban population and therefore demand for maize. The past trend of maize cultivation area, and as a result, fertilizer consumption, actually, was not simple in a sense.

Other major factor is development of maize cultivation by subsistence farmer to commercial cultivation. Generally, even the subsistence farmers are aware of the effectiveness of fertilizer application on yield increase. Once they happens to have a surplus product to be marketed, they will buy fertilizer and try to increase their harvest. Of course the natural disaster such as drought often hampers their effort. The conspicuous increase in the fertilizer consumption in 1975 and onwards has resulted from such

demand increase by small scale commercial farmers developed from subsistence agriculture.

4.2 Outlook of Factors Affecting the Fertilizer Demand, and Projection of Demand for Phosphate Fertilizer

(1) Projection of Maize Cultivation Area

In the projection of demand for fertilizer, the cultivation area of maize, which is the major affecting factor on fertilizer demand, was firstly projected, and then, the fertilizer demand was projected based on it (Figure II-4).

The data on maize cultivated area for total Zambia is available from 1974, but the province-wise data is available only from 1982. Therefore, in the projection of maize cultivation area, the area for total Zambia was projected first, using the past trend, the result of which was checked by the maximum cultivated area culculated on the basis of assumption that all the maize required will be produced domestically. After that, the total cultivated area was broken down by province using the trend on province-wise ratio of total cultivated area.

(2) Fertilizer Demand Projection

Multiplying the 112 N kg/ha, 40 P_2O_5 kg/ha, and 20 K_2O kg/ha of recommended dosages by the above-forecast province-wise cultivated areas, the potential demand was projected. Also, the realization rate of the potential demand in the past, by province, was calculated and extrapolated to the future rate using trend analysis. Then, multiplying the province-wise potential demand by the future realization rate of potential demand, the demand for fertilizer was projected by province.

The result of projections for the phosphate fertilizer is given in Table II-19., and the data for each step of projection are attached in Annex II-6.

4.3 Outlook of Demand for FMP

What extent of demand for phosphate fertilizer will be materialized as the demand for FMP, depends on the sales promotion measures to be taken when FMP is introduced, the level of sales price as well as the support given by the leaders in the agricultural sector. In this projection, these factors are assumed to be fulfilled sufficiently.

The cultivable area on which the FMP can be applied is widely distributed in Zambia. The salable volume of FMP depends on the suppliable amount of FMP from this project. The sales volume of the FMP with assumption that the sales is confined to the acidic soil area, is shown in Table II-20.

4.4 Outlook of Demand for SSP

In the case of SSP, there are two areas of demand, namely, for straight fertilizer and for raw material of compound fertilizer. In order to sell it as a straight fertilizer, it is necessary to be granulated. Marketing as compound fertilizer is much easier than selling it as a straight fertilizer, since only a slight modification is required for the present application practice. However, salable price of SSP to the producer of compound fertilizer will be very low in this case.

SSP is applicable for all the areas where phosphate demand exists, since it contains water-soluble phosphate and is sold as compound fertilizer. Thus, the market quantity may be decided by the potential amount that can be supplied instead of market size. The market volume of the SSP with assumption that 30% of requirement of phosphate raw material of compound fertilizer is fulfilled by the SSP, is given in Table II-21.

4.5 Projection of Monthly Shipment of FMP/SSP

The planting season in Zambia is concentrated to a short period, the rainy season from October through January. The 89% of fertilizer for basal dressing is shipped from August through January, and further, of which 65% is concentrated from October through December (Table II-22). However, the fertilizer is applied with the start of rainy season, and the start of rainy season changes year by year, threrefore the monthly shipment ratio fluctuates year to year.

As a result, the stock to be kept should be fairly high compared with the shipment volume to prevent the inventory from shortage. Table II-23 shows the required stock level in the factory and distribution process down to depots at the end of each month at various degree of risk of inventory shortage. In order to make the risk less than 0.3% (level 3), the stock equivalent to 89% of yearly shipment is required at the end of August, and it will be 64% at 32% of the risk rate (level 1).

In order to lower the stock level, it is recommended to encourage the advance take-off by farmers using such measures as extension of credit for fertilizer purchase or paying the incentive bonus for earlier take-off.

Table and Figure

for

Part II

MARKET ASPECTS

Table II-1 to Table II-23

and

Figure II-1 to Figure II-4

Table II-1 GDP BY KIND OF ECONOMIC ACTIVITY IN ZAMBIA

(Unit: % of GDP)

	1980	1981	1982	1983	1984	1985	Average Annual % Change 1985/80
Aggregate Gross Domestic Product (GDP)*	1,996	2,119	2,059	2,019	2,012	2,080	0.8
Sectoral Breakdown							
Agriculture, Forestry, Fishing and Hunting	15.2	15.5	14.1	15.6	16.5	17.5	3.6
Mining and Quarrying	10.3	10.1	10.4	11.0	9.9	9.1	-1.6
Manufacturing	19.2	20.3	20.2	19.1	19.3	20.4	2.0
Electricity, Gas and Water	3.3	3.4	3.7	3.6	3.5	3.6	2.3
Construction	5.2	3.7	4.1	4.4	4.4	3.7	-5.7
Wholesale and Retail Trade	9.8	9.2	8.7	8.5	8.3	8.3	-2.5
Hotels, Bar and Restaurants	2.0	2.5	2.6	2.8	2.4	2.5	5.4
Transport, Communications and Storage	5.9	5.6	5.8	5.9	5.8	5.8	0.3
Financial Institutions, Insurance, etc.	67	65	71	66	63	62	-1.5
Real Estate and Business Services	7.3	7.2	7.6	8.3	8.9	8.7	4.4
Community, Social and Personal Services	17.3	18.5	19.1	17.6	17.6	17.6	1.1
Import Duties	2.1	1.7	1.4	0.9	0.9	0.9	-15.6
Less Imputed Bank Charges	1.0	0.8	1.0	0.9	0.9	0.8	-2.2

Note: * GDP in million Kwacha at 1975 price.

Source: NCDP "Economic Review and Annual Plan, 1986".

Table II-2 SECTORIAL DISTRIBUTION OF EMPLOYERS IN EACH SECTOR

	June 1979		June 1984	
	Number	% of Ind. Total	Number	% of Ind. Total
Agriculture, Forestry and Fisheries	31,850	8.5	35,400	9.7
Mining and Quarrying	61,980	16.6	58,470	16.0
Manufacturing	44,960	12.0	48,200	13.2
Electricity and Water	7,730	2.1	7,950	2.2
Construction and Allied Repairs	42,380	11.3	33,610	9.2
Distribution, Restaurants and Hotels	36,720	9.8	30,250	8.3
Transport and Communications	24,560	6.6	24,000	6.6
Finance, Insurance and Other Business Services	20,140	5.4	22,410	6.1
Community, Social and Personal Services	103,550	27.7	105,010	28.8
Industries Total	373,870	100.0	365,300	100.0
Domestic Servants	33,874		45,760*	

Source: Central Statistical Office.

Note: * June 1983.

Table II-3 ESTIMATED CROPPED AREA OF MAIZE BY COMMERCIAL FARMS AND NON-COMMERCIAL FARMS

	Commercial Farms		Non-Commercial Farms		Total
	'000 ha*1	% of Total	'000 ha*2	% of Total	'000 ha
1974/75	194.1	24.1	611.1	75.9	805.2
1976/77	268.1	30.1	623.1	69.9	891.2
1977/78	485.0	48.4	516.8	51.6	1,001.8

Notes: *1 Bank of Zambia, "Annual Reports".

*2 Estimated using the statistical figure on number of bags of maize produced by non-commercial farms and average yield in 1982 by commercial sector; the figure on number of bags was estimated by sampling surveys made by CSO ("Agricultural and Pastoral Production, non-commercial sector").

Table II-4 CHANGES IN HARVESTED AREA BY CATEGORIES OF FARMERS

	1974		1983		Change Area	
	Estimated Area ('000 ha)	Percent (%)	Estimated Area ('000 ha)	Percent (%)	Estimated Area ('000 ha)	1974-83 Percent (%)
1. Traditional Farmers	1,578	78	1,136	51	-442	-28
2. Emergent Farmers	356	18	944	43	+588	+165
- Improved Village Farmers	215	11	637	29	+422	+196
- Organized Small Holder Schemes	68	3	130	6	+62	+91
- Emergent Middle Farmers	73	4	177	8	+104	+142
3. Large-Scale Commercial Farmers	81	4	135	6	+54	+67
4. Total	2,015	100	2,215	100	+200	+10

Source: The 3rd National Development Plan, 1979-1983.

Table II-5 NUMBER OF FARM BY MANAGEMENT TYPE AND OWN LAND, 1980

(Unit: Number of Farms)

Province	Commercial Farm			Tradition-al Farm	Total
	40 ha and above	11-39 ha	1-10 ha		
Northern	-	90	7,400	111,900	119,390
Luapula	-	50	2,050	73,600	75,700
Northwestern	-	80	2,900	53,600	56,580
Copperbelt	-	490	2,000	17,900	20,390
Central	300	7,630	21,400	18,400	47,730
Lusaka	90	1,910	4,300	13,400	19,700
Eastern	20	3,100	27,000	80,900	111,020
Southern	320	8,000	49,900	7,500	65,720
Western	-	-	5,450	85,400	90,850
Total	730	21,350	122,400	462,600	607,080

Source: National Commission for Development Planning, Agricultural Baseline Data for Planning, 1983.

Table II-6 AVERAGE HECTAREAGE OF LAND OWNED BY ONE COMMERCIAL FARM
- AS OF SEPTEMBER 30, 1977 -

Province:	Central			Southern			Copperbelt and Others			Total Zambia		
Hectareage range:	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)	(A)	(B)	(C)
0- 79	490	43.1	26	374	45.7	29	126	44.1	9	990	44.2	25
80- 199	89	7.8	115	154	18.8	73	29	10.1	82	272	12.1	87
200- 399	65	5.7	254	56	6.8	253	74	25.9	78*	195	8.7	187*
400 799	149	13.1	608	66	8.1	428	9	3.1	329*	224	10.0	544
800 1,999	228	20.1	1,115	70	8.5	1,287	24	8.4	1,089	322	14.4	1,150
2,000+	116	10.2	7,352	99	12.1	6,992	24	8.4	15,533	239	10.7	8,024
Total	1,137	100.0	1,088	819	100.0	1,034	286	100.0	1,438	2,242	100.0	1,113

Source: CSO, "Agricultural and Pastoral Production, Commercial Farms, 1976-77."

Notes: (A) Number of holdings
(B) % of total in (A)
(C) Average hectareage of land owned by one commercial farm. (ha/farm)
* The figures do not coincide with the hectareage ranges.

Table II-7 CHARACTERISTICS OF AGRICULTURAL PRODUCTION BY COMMERCIAL FARM - 1976/1977 -

Hectareage Range	Average Hectareage of Land per Farm (ha)	Average Cultivated Crop Land per Farm (ha)	Ratio of Maize Marketed (% of Total Production)	Average Yield of Maize (ton/ha)
0- 79	25	14	93.4	2.8
80- 199	87	31	91.6	3.1
200- 399	187	53	94.8	3.9
400- 799	544	93	98.3	1.6*1
800-1,999	1,150	151	93.6	4.2
2,000+	8,024	263	96.4	2.1*2
Total	1,113	73	95.0	2.7

Notes: *1 3.9 tons/ha in Southern province, while 1.4 tons/ha in Central province and other provinces.

*2 4.9 tons/ha in Southern province, while 1.7 tons/ha in Central province and 2.6 tons/ha in other provinces.

Table II-8 CHANGE IN CROP PRODUCTION IN ZAMBIA

	1982				1983				1984				1985			
	Area (A)	Prod. (B)	% Mktd (C)	Yield (D)	Area (A)	Prod. (B)	% Mktd (C)	Yield (D)	Area (A)	Prod. (B)	% Mktd (C)	Yield (D)	Area (A)	Prod. (B)	% Mktd (C)	Yield (D)
Maize	454.5	750.2	68.4	1.6	546.7	935.3	56.8	1.7	506.5	871.7	65.5	1.7	581.9	1122.4	56.7	1.9
Sunflower	41.5	26.7	79.7	0.7	48.1	34.9	87.2	0.8	57.7	43.0	94.0	0.8	62.6	42.4	68.1	0.7
Soybeans	5.3	7.3	53.1	1.4	5.0	8.0	86.7	1.6	9.4	13.2	72.6	1.4	9.8	14.7	71.9	1.5
Groundnuts	22.4	9.4	8.3	0.4	31.4	11.0	9.5	0.3	29.5	13.3	8.7	0.5	31.9	14.5	16.7	0.5
Paddy Rice	5.9	5.3	54.9	0.9	7.0	9.6	52.6	1.4	8.7	9.3	58.7	1.0	10.7	11.2	56.2	0.7
Seedcotton	23.9	12.8	100.0	0.5	33.1	20.7	100.0	0.6	52.0	43.9	100.0	0.8	45.8	30.3	100.0	0.7
Sorghum	21.5	14.0	1.1	0.6	16.6	12.5	0.8	0.7	21.8	15.0	1.9	0.7	24.8	20.2	5.5	0.8
Virginia Tobacco	2.2	2.1	100.0	1.0	2.2	2.3	99.9	1.1	2.1	2.5	99.9	1.2	1.5	2.1	102.7	1.5
Burley Tobacco									0.7	0.5	99.2	67.7	0.6	0.5	117.3	74.3
Millet					20.0	12.7	0.8	0.6	19.0	13.5	0.1	0.7	22.4	19.4	0.2	0.9
Beans	14.4	4.2	8.5	0.3	17.7	6.0	1.4	0.4	7.6	5.4	2.0	0.7	8.3	5.5	8.5	0.6

Source: MAWD: "Quarterly Agricultural Statistical Bulletin, Oct./Dec., 1985"

Notes: Unit Area '000 ha
Production '000 ton
% marketed % of production
Yield ton/ha

Table II-9 IMPORT AND EXPORT OF MAJOR CROPS

(Unit: '000 ton)

	Maize		Rice	Wheat
	Import	Export	Import	Import
1971		0.8		
1972		0.1		
1973		5.0		
1974		11.0		
1975		1.6		
1976	0.0	0.8	90.0	94.4
1977	0.4	2.5	6.0	96.5
1978	0.0	6.0	6.5	41.6
1979	66.4		5.7	128.5
1980	294.3		7.2	114.0
1981	93.5		6.5	53.8
1982	68.8		8.6	130.4
1983	126.0		12.3	85.3
1984	81.1		n.a.	64.0

Source: MAWD

Notes: 0.0 means less than 50 tons.

Table II-10 CONSUMPTION OF FERTILIZER IN ZAMBIA, 1972-1985

(Unit: ton)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
COMPOUND	66,490	50,721	48,402	74,784	78,272	90,225	77,140	80,136	110,428	115,978	128,666	92,606	79,298	112,260
STRAIGHT N	44,980	32,554	50,846	56,956	65,487	75,503	50,421	61,270	82,949	93,447	82,239	69,174	58,377	91,537
STRAIGHT P	498	280	351	1,472	2,076	1,610	1,896	1,725	2,568	2,217	807	1,445	467	1,060
STRAIGHT K	832	1,226	2,751	327	39	169	149	202	219	290	108	171	214	144
TOTAL	112,800	84,781	102,350	133,695	150,774	167,507	130,077	145,368	196,363	218,791	217,868	165,798	143,894	211,180
Total in Nutrient														
N	21,922	16,325	19,473	33,044	39,828	45,283	31,100	38,263	53,170	57,766	54,396	43,616	38,144	55,729
P205	6,761	5,107	4,875	12,211	13,784	15,584	13,397	14,243	18,884	20,370	21,731	15,799	12,298	19,647
K20	4,152	3,476	4,239	5,238	4,644	5,499	5,442	4,645	5,678	6,316	8,008	6,265	4,585	7,876

Source: NAMBOARD

Table II-11 SUPPLY AND CONSUMPTION OF FERTILIZER IN ZAMBIA, 1983-1986

(Unit: 1,000 tons of product)

	Production	Imports		Total Supply	Consumption
	(A)	End Products (B)	Raw Materials	(A+B)	(C)
1983	72.6	132.9	25.5	205.5	165.8
1984	77.8	195.2	23.1	273.0	143.9
1985	19.9	30.5	-	50.4	211.2
1986	59.5	143.6	N.A.	203.1	153.8

Sources: NCZ and NAMBOARD

Table II-12 SALES PRICE AND PURCHASE PRICE OF FERTILIZER BY NAMBOARD

(Unit: K./ton)

	1980	1981	1982	1983	1984	1985	1986
Compound D							
Sales Price (A1)	232.0	235.0	299.0	482.0	535.0	535.0	1,600.0
Purchase Price from NCZ (B1)	-	-	612.0	611.0	611.0	664.0	1,860.0
(A1/B1) (%)	-	-	48.9	78.9	87.6	80.6	86.0
Landed Cost of Imported Fertilizer (C1)	304.0	446.0	269.0	439.3	492.3	N.I.	3,825.0*
(A1/C1) (%)	76.3	52.7	111.2	109.7	108.7	-	41.8
(B1/C1) (%)	-	-	227.5	139.1	124.1	-	48.6
Urea							
Sales Price (A2)	233.0	219.0	299.0	482.0	535.0	535.0	1,300.0
Landed Cost of Imported Fertilizer (C2)	400.0	406.0	268.0	462.6	697.4	N.A.	2,775.0*
(A2/C2) (%)	58.3	53.9	111.6	104.2	76.7	-	46.8
Ammonium Nitrate							
Sales Price (A3)	158.6	202.6	281.0	464.0	517.0	517.0	1,120.0
Purchase Price from NCZ (B3)	378.8	424.0	531.0	564.0	617.0	710.0	1,860.0
(A3/B3) (%)	41.9	47.8	52.9	82.3	83.8	72.8	60.2

Notes: A = Ex-NAMBOARD depot: Price in October in each year.
B = Ex-factory
C = C.I.F. Lusaka
N.I. = No import
N.A. = Not available
- = No production
* = As of April, 1987. (K.15/US$)

Table II-13 COMPARISON OF FERTILIZER COSTS PER HECTARE

(Unit: K./ha)

		1975	1980	1983	1985	1986
Present Application Practice						
CX-D	4 bags	26.20	38.40	96.40	107.00	320.00
Urea	4 bags	27.00	38.60	96.40	107.00	260.00
Total (A)		53.20	77.00	192.80	214.00	580.00
Application by Combination of Straight Fertilizers						
DAP	1.739 bags	15.81	26.57	61.27	67.68	155.53
MOP	0.667 bags	2.40	3.20	14.07	15.84	36.69
Urea	3.504 bags	23.65	33.81	84.45	93.73	227.76
AS	1.492 bags	7.16	10.82	33.64	37.60	71.62
Total (B)		49.02	74.40	193.44	214.86	491.58
A/B		1.08	1.03	1.00	1.00	1.18

Note: DAP price was estimated using the following formula:
(DAP price) = (TSP price) + (Urea price) x 18/46

Table II-14 PROJECTED PRICES OF FMP/SSP
- BASE CASE -

Name of Fertilizer	Fertilizer Cost without FMP/SSP (Case 1)						Fertilizer Cost with FMP/SSP (Case 2)					
	Application Using Straight Fertilizers (Case 1.1)			Application Using Compound Fertilizer and Urea (Case 1.2)			Application Using SSP (Case 2.1)			Application Using FMP (Case 2.2)		
	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha
Compound				4	114	456	4.444	103	456	3.338	114	381
Urea	3.504	104	364	4	104	416	4.000	104	416	3.913	104	407
AS	1.492	72	107							0.192	72	14
FMP										1.333	53	70
DAP	1.739	137	238									
MOP	0.667	92	61									
Total Cost (K./ha)			770			872			872			872

Notes: 1) Ex-factory price of FMP: K.880/ton (US$110/ton)

2) Ex-factory price of SSP-Compound: K.1,880/ton (US$235/ton)
(less) raw material cost other than SSP K.1,643/ton
Maximum allowable SSP cost without formulation cost K.237/ton (SSP 0.368 ton: see Annex II-5)
Maximum allowable SSP price (delivered at compound fertilizer factory) K.644/ton (US$81/ton)

Table II-15 PROPOSED CHANGE IN FERTILIZER APPLICATION BY INTRODUCTION OF FMP OR SSP

Case	Kind of Fertilizer	Nutrient Content (N-P2O5-K2O-S)	Application Amount per Ha.				
			Bags	N Kg	P2O5 Kg	K2O Kg	S Kg
Present Practice	CX-D	10-20-10-10	4.000	20.0	40.0	20.0	20.0
	Urea	46-0-0-0	4.000	92.0	-	-	-
	Total		8.000	112.0	40.0	20.0	20.0
Combination of Straight Fertilizers	Urea	46-0-0-0	3.504	80.6	-	-	-
	AS	21-0-0-24	1.492	15.7	-	-	17.9
	DAP	18-46-0-2.4	1.739	15.7	40.0	-	2.1
	MOP	0-0-60-0	0.667	-	-	20.0	-
	Total		7.402	112.0	40.0	20.0	20.0
Use of SSP as a Source of Phosphate in Compound Fertilizer (CX-DS)	CX-DS	9-18-9-9.5	4.444	20.0	40.0	20.0	21.1
	Urea	46-0-0-0	4.000	92.0	-	-	-
	Total		8.444	112.0	40.0	20.0	21.1
Use of FMP as a Straight Fertilizer with Compound Fertilizer (CX-DF)	CX-DF	12-16-12-10.6	3.338	20.0	26.7	20.0	17.7
	FMP	0-20-0-0	1.333	-	13.3	-	-
	Urea	46-0-0-0	3.913	90.0	-	-	-
	AS	21-0-0-24	0.192	2.0	-	-	2.3
	Total		8.776	112.0	40.0	20.0	20.0

Table II-16 PROJECTED PRICES OF FMP/SSP
- Scenario 1 -

Name of Fertilizer	Fertilizer Cost without FMP/SSP						Fertilizer Cost with FMP		
	Application Using Straight Fertilizers (Case 1.1)			Application Using Compound Fertilizer and Urea (Case 1.2)			Application Using FMP (Case 2.2)		
	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha
Compound				4	91	364	3.338	91	304
Urea	3.504	74	259	4	74	296	3.913	74	290
AS	1.492	55	82				0.192	55	11
FMP							1.333	41	55
								===	===
DAP	1.739	92	160						
MOP	0.667	63	42						
Total Cost (K./ha)			543			660			660

Notes: Ex-factory price of FMP: US$80/ton

Maximum acceptable price of FMP: U$96/ton

1) DAP price was assumed using the following formula;
(DAP price)=[(TSP price)+(Urea price)*18/46]*0.9
2) Ex-factory prices of FMP after adding the subsidy are as follows:

Level of subsidy	Price of FMP
20 %	US$100/ton
25	107
30	114

Table II-17 (1) PROJECTED PRICES OF FMP - Scenario 2 -

Formulation Cost of Compound Fertilizer: 15% of Total Cost

Name of Fertilizer	Fert. cost w/o FMP/SSP			Fertilizer Cost with FMP		
	Application Using Compound Fertilizer and Urea			Application Using FMP		
	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha
Compound	4	159	636	3.338	161	538
Urea	4	104	416	3.913	104	407
AS				0.192	72	14
FMP				1.333	70	93
					===	===
Total Cost (K./ha)			1,052			1,052

Notes: Ex-factory price of FMP: US$153/ton

Table II-17 (2) PROJECTED PRICES OF FMP - Scenario 2 -

Formulation Cost of Compound Fertilizer: 25% of Total Cost

Name of Fertilizer	Fert. cost w/o FMP/SSP			Fertilizer Cost with FMP		
	Application Using Compound Fertilizer and Urea			Application Using FMP		
	bag/ha	K./bag	K./ha	bag/ha	K./bag	K./ha
Compound	4	179	716	3.338	181	604
Urea	4	104	416	3.913	104	407
AS				0.192	72	14
FMP				1.333	80	107
					===	===
Total Cost (K./ha)			1,132			1,132

Notes: Ex-factory price of FMP: US$178/ton

Table II-18 ESTIMATE OF SSP PRICE TO BE USED AS RAW MATERIAL OF COMPOUND FERTILIZER (CX-SSP) - SCENARIO 2 -

	CX-D			CX-DS		
	Material Requirement (ton/ton)	Unit Price	Cost	Material Requirement (ton/ton)	Unit Price	Cost
AN	0.139	1,868	260	0.140	1,868	262
AS	0.217	1,448	314	0.079	1,448	114
DAP	0.024	2,736	66	0.170	2,736	465
TSP	0.379	2,288	867	0.104	2,288	238
SOP	0.187	2,968	555	0.190	2,968	564
Total	0.946		2,062	0.683		1,643
Allowable SSP cost*1						419
Unit price (K./ton)						1,139
(US$/ton)						142

Note : *1 1ton of CX-DS requires 0.368 tons of SSP.

Table II-19 PROJECTED DEMAND FOR PHOSPHATE FERTILIZER IN ZAMBIA

(Unit: '000 P2O5 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
1982	21.7	4.20	0.73	3.46	0.17	3.29	2.42	0.19	7.18	0.08
1983	15.8	3.44	0.52	3.58	0.33	1.69	1.54	0.13	4.31	0.16
1984	12.3	3.02	0.70	1.23	0.29	1.37	1.45	0.03	4.07	0.14
1985	19.6	4.29	0.97	4.95	0.32	1.63	1.42	0.22	5.47	0.39
Projected										
1986	22.9	3.9	1.3	3.5	0.4	2.7	2.9	0.2	7.8	0.2
1987	24.4	4.0	1.5	3.4	0.5	2.8	3.2	0.2	8.5	0.3
1988	25.8	4.0	1.7	3.4	0.5	3.0	3.4	0.2	9.3	0.3
1989	27.3	4.1	1.9	3.4	0.6	3.1	3.6	0.2	10.1	0.3
1990	28.8	4.2	2.0	3.4	0.6	3.3	3.8	0.2	10.9	0.4
1991	30.1	4.3	2.1	3.4	0.7	3.4	3.9	0.2	11.7	0.4
1992	31.3	4.4	2.2	3.4	0.7	3.6	4.0	0.2	12.4	0.4
1993	32.4	4.5	2.3	3.5	0.7	3.7	4.0	0.2	13.1	0.4
1994	33.7	4.7	2.3	3.6	0.7	3.8	4.1	0.2	13.8	0.5
1995	34.8	4.8	2.4	3.6	0.8	4.0	4.1	0.2	14.4	0.5
1996	36.0	5.0	2.4	3.7	0.8	4.1	4.2	0.2	15.1	0.5
1997	37.1	5.1	2.5	3.8	0.8	4.2	4.3	0.2	15.6	0.6
1998	38.1	5.3	2.5	3.9	0.8	4.3	4.3	0.2	16.2	0.6
1999	39.2	5.5	2.6	4.0	0.8	4.4	4.4	0.2	16.7	0.6
2000	40.2	5.7	2.6	4.1	0.8	4.6	4.4	0.2	17.2	0.6
2001	41.2	5.8	2.6	4.2	0.8	4.7	4.5	0.3	17.7	0.6
2002	42.3	6.0	2.7	4.3	0.8	4.8	4.6	0.3	18.1	0.7
2003	43.4	6.2	2.7	4.5	0.9	4.9	4.6	0.3	18.6	0.7
2004	44.4	6.4	2.8	4.6	0.9	5.0	4.7	0.3	19.0	0.7
2005	45.3	6.6	2.8	4.7	0.9	5.1	4.8	0.3	19.4	0.7
2006	46.1	6.8	2.8	4.8	0.9	5.2	4.8	0.3	19.8	0.7
2007	47.1	7.0	2.9	5.0	0.9	5.3	4.9	0.3	20.1	0.7
2008	48.0	7.2	2.9	5.1	0.9	5.4	5.0	0.3	20.5	0.7
2009	49.3	7.4	3.0	5.3	1.0	5.5	5.1	0.3	20.9	0.8
2010	50.1	7.6	3.0	5.4	1.0	5.6	5.1	0.3	21.3	0.8

Table II-20 SALES VOLUME OF PHP IN ZAMBIA

(Unit: '000 P2O5 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
1986	9.5	1.3	1.3	1.2	0.4	0.0	2.9	0.2	2.0	0.2
1987	10.2	1.3	1.5	1.1	0.5	0.0	3.2	0.2	2.1	0.3
1988	10.8	1.3	1.7	1.1	0.5	0.0	3.4	0.2	2.3	0.3
1989	11.6	1.4	1.9	1.1	0.6	0.0	3.6	0.2	2.5	0.3
1990	12.2	1.4	2.0	1.1	0.6	0.0	3.8	0.2	2.7	0.4
1991	12.7	1.4	2.1	1.1	0.7	0.0	3.9	0.2	2.9	0.4
1992	13.2	1.5	2.2	1.1	0.7	0.0	4.0	0.2	3.1	0.4
1993	13.6	1.5	2.3	1.2	0.7	0.0	4.0	0.2	3.3	0.4
1994	14.1	1.6	2.3	1.2	0.7	0.0	4.1	0.2	3.5	0.5
1995	14.4	1.6	2.4	1.2	0.8	0.0	4.1	0.2	3.6	0.5
1996	14.8	1.7	2.4	1.2	0.8	0.0	4.2	0.2	3.8	0.5
1997	15.3	1.7	2.5	1.3	0.8	0.0	4.3	0.2	3.9	0.6
1998	15.6	1.8	2.5	1.3	0.8	0.0	4.3	0.2	4.1	0.6
1999	15.9	1.8	2.6	1.3	0.8	0.0	4.4	0.2	4.2	0.6
2000	16.2	1.9	2.6	1.4	0.8	0.0	4.4	0.2	4.3	0.6
2001	16.5	1.9	2.6	1.4	0.8	0.0	4.5	0.3	4.4	0.6
2002	17.0	2.0	2.7	1.4	0.8	0.0	4.6	0.3	4.5	0.7
2003	17.5	2.1	2.7	1.5	0.9	0.0	4.6	0.3	4.7	0.7
2004	17.8	2.1	2.8	1.5	0.9	0.0	4.7	0.3	4.8	0.7
2005	18.2	2.2	2.8	1.6	0.9	0.0	4.8	0.3	4.9	0.7
2006	18.4	2.3	2.8	1.6	0.9	0.0	4.8	0.3	5.0	0.7
2007	18.7	2.3	2.9	1.7	0.9	0.0	4.9	0.3	5.0	0.7
2008	19.0	2.4	2.9	1.7	0.9	0.0	5.0	0.3	5.1	0.7
2009	19.7	2.5	3.0	1.8	1.0	0.0	5.1	0.3	5.2	0.8
2010	19.8	2.5	3.0	1.8	1.0	0.0	5.1	0.3	5.3	0.8

Table II-21 SALES VOLUME OF SSP IN ZAMBIA

(Unit: '000 P2O5 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
1991	9.03	1.29	0.63	1.02	0.21	1.02	1.17	0.06	3.51	0.12
1992	9.39	1.32	0.66	1.02	0.21	1.08	1.20	0.06	3.72	0.12
1993	9.72	1.35	0.69	1.05	0.21	1.11	1.20	0.06	3.93	0.12
1994	10.11	1.41	0.69	1.08	0.21	1.14	1.23	0.06	4.14	0.15
1995	10.44	1.44	0.72	1.08	0.24	1.20	1.23	0.06	4.32	0.15
1996	10.80	1.50	0.72	1.11	0.24	1.23	1.26	0.06	4.53	0.15
1997	11.13	1.53	0.75	1.14	0.24	1.26	1.29	0.06	4.68	0.18
1998	11.43	1.59	0.75	1.17	0.24	1.29	1.29	0.06	4.86	0.18
1999	11.76	1.65	0.78	1.20	0.24	1.32	1.32	0.06	5.01	0.18
2000	12.06	1.71	0.78	1.23	0.24	1.38	1.32	0.06	5.16	0.18
2001	12.36	1.74	0.78	1.26	0.24	1.41	1.35	0.09	5.31	0.18
2002	12.69	1.80	0.81	1.29	0.24	1.44	1.38	0.09	5.43	0.21
2003	13.02	1.86	0.81	1.35	0.27	1.47	1.38	0.09	5.58	0.21
2004	13.32	1.92	0.84	1.38	0.27	1.50	1.41	0.09	5.70	0.21
2005	13.59	1.98	0.84	1.41	0.27	1.53	1.44	0.09	5.82	0.21
2006	13.83	2.04	0.84	1.44	0.27	1.56	1.44	0.09	5.94	0.21
2007	14.13	2.10	0.87	1.50	0.27	1.59	1.47	0.09	6.03	0.21
2008	14.40	2.16	0.87	1.53	0.27	1.62	1.50	0.09	6.15	0.21
2009	14.79	2.22	0.90	1.59	0.30	1.65	1.53	0.09	6.27	0.24
2010	15.03	2.28	0.90	1.62	0.30	1.68	1.53	0.09	6.39	0.24

Table II-22 MONTHLY SHIPMENT PATTERN OF BASAL DRESSING, 1983-1985

(Unit: % of yearly shipment total)

Month	1983	1984	1985	Average of 1983-85	Standard Deviation
January	4.9	5.1	11.4	7.2	3.7
February	0.8	1.1	3.1	1.7	1.2
March	0.9	3.0	0.4	1.4	1.4
April	1.6	3.9	0.8	2.1	1.6
May	0.3	4.4	0.7	1.8	2.3
June	0.4	6.8	1.2	2.8	3.5
July	2.6	0.3	1.0	1.3	1.2
August	7.4	5.5	3.8	5.6	1.8
September	16.8	9.0	6.9	10.9	5.2
October	22.1	14.4	13.7	16.7	4.7
November	27.9	26.4	18.6	24.3	5.0
December	14.2	20.1	38.4	24.2	12.6

Table II-23 MONTHLY STOCK REQUIREMENT

(Unit: % of yearly shipment total)

	Monthly Shipment		Minimum Ending Stock Requirement		
	Average of 1983-85	Standard Deviation	Level 1	Level 2	Level 3
January	7.2	3.7	22.0	34.6	47.2
February	1.7	1.2	28.6	41.2	53.8
March	1.4	1.4	35.6	48.2	60.8
April	2.1	1.6	41.8	54.4	67.0
May	1.8	2.3	48.4	61.0	73.6
June	2.8	3.5	53.9	66.5	79.1
July	1.3	1.2	61.0	73.6	86.2
August	5.6	1.8	63.7	76.3	88.9
September	10.9	5.2	61.1	73.7	86.3
October	16.7	4.7	52.8	65.4	78.0
November	24.3	5.0	36.8	49.4	62.0
December	24.2	12.6	20.9	33.5	46.1

Note: Minimum ending stock requirement is estimated at the following three levels of probability of risk for the shipment volume to exceed the stock at:

Level 1 32%
Level 2 5%
Level 3 0.3%

Figure II-1 FLOW OF FERTILIZER DISTRIBUTION

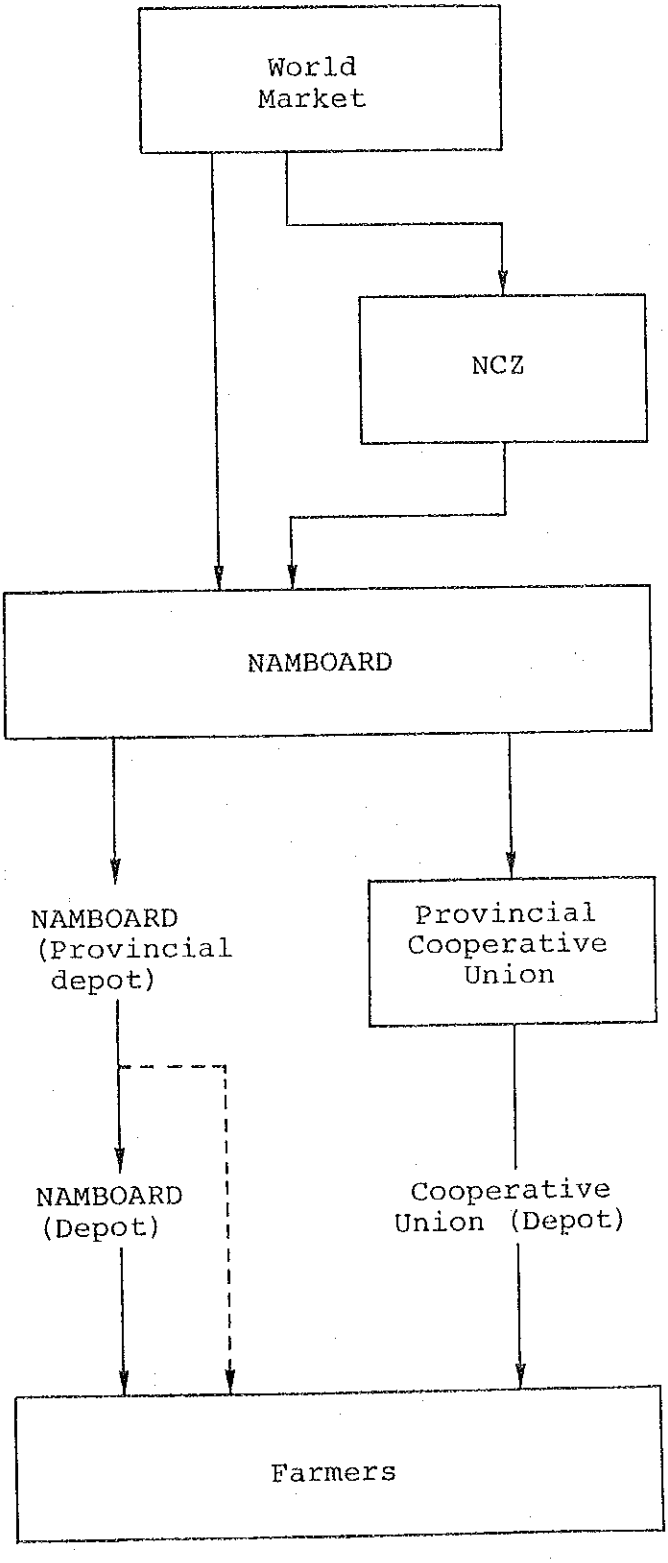


Figure II-2 PHYSICAL DISTRIBUTION FLOW OF IMPORTED FERTILIZER

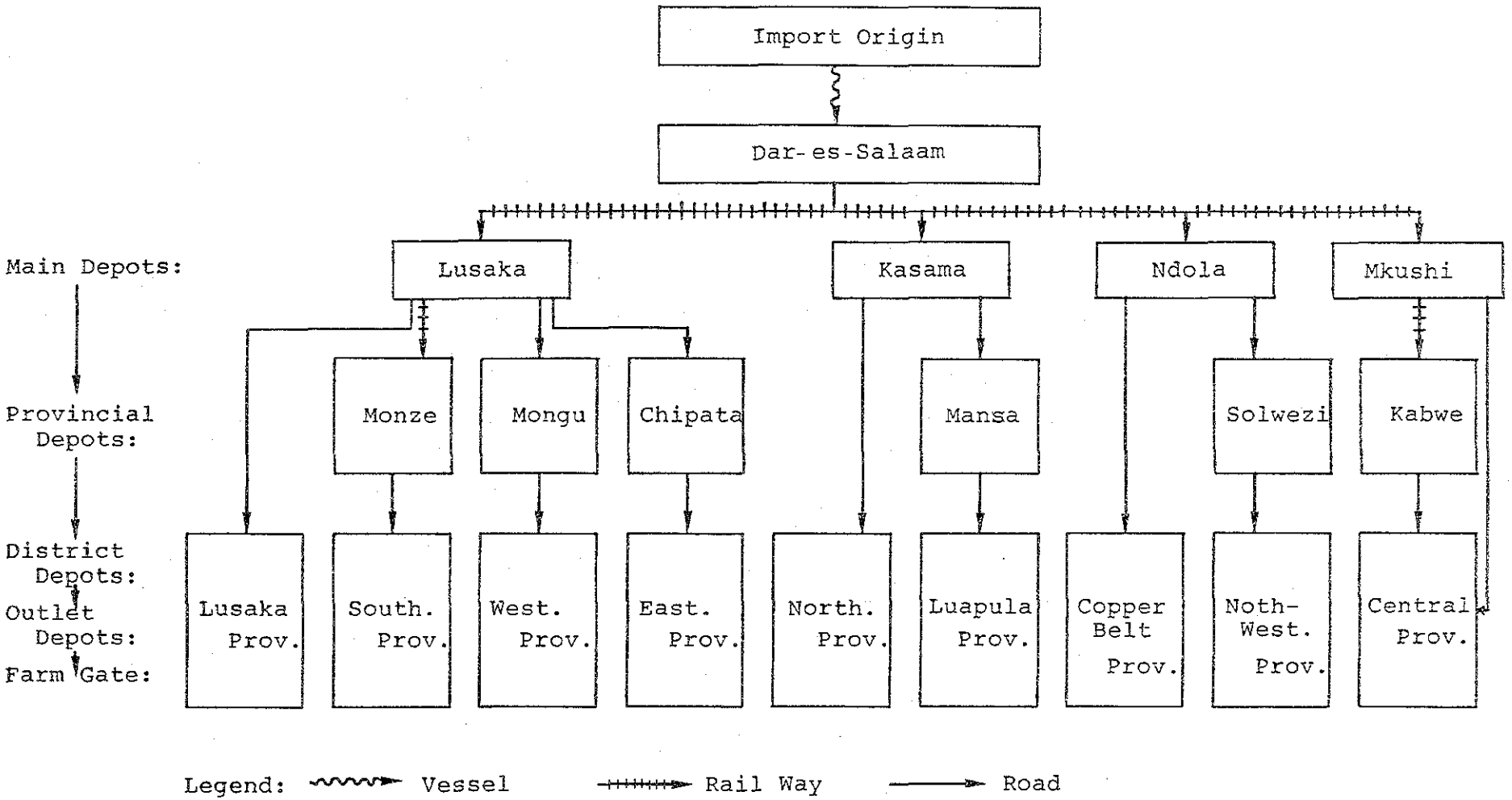
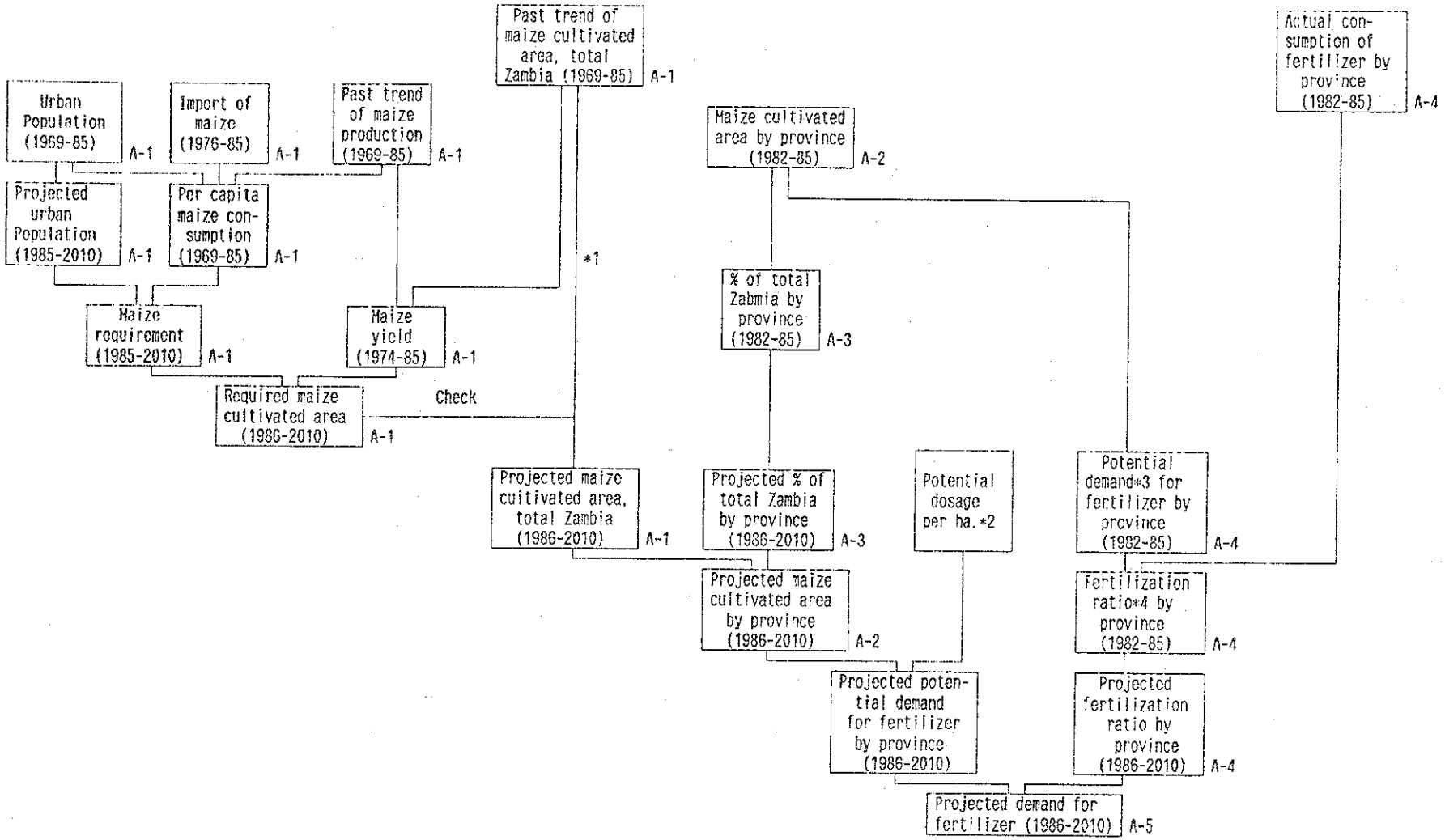


Figure II-3 CLASSIFICATION OF AREA IN VIEW OF USE OF FMP AND LIME

Figure II-4 PROCEDURE OF PROJECTION OF DEMAND FOR PHOSPHATE FERTILIZER



Notes: *1 y = -1,670.86 + 26.5985x (r=0.702); where y= maize cultivated area, x = year
*2: N 112kg/ha P2O4 40kg/ha K2O 20kg/ha
*3 Potential dosage (kg/ha) x Cultivated area (ha)
*4: Actual consumption / Potential demand
*5 "A-x" means the number of tables attached in Annex II-6.