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List of Annex

Annex I-1

SCOPE OF WORKS FOR THE FEASIBILITY STUDY

SCOPE OF WORK

FOR

THE FEASIBILITY STUDY

ON

THE ESTABLISHMENT OF A FUSED MAGNESIUM PHOSPHATE FERTILIZER PLANT

IN

THE REPUBLIC OF ZAMBIA

AGREED UPON BETWEEN

INDECO LTD

AND

THE JAPAN INTERNATIONAL COOPERATION AGENCY

Lusaka, August 19th 1986

Mr.Dixie ZULU
Managing Director
INDECO LTD.

INDECO LIMITED
P.O. BOX 31935
LUSAKA

Mr.Keiji MIURA
Leader of the Preliminary
Survey Team
The Japan International
Cooperation Agency

I. Introduction

In response to the request of the Government of the Republic of Zambia,(hereinafter referred to as "Zambia") the Government of Japan has decided to conduct a feasibility study on the establishment of a fused magnesium phosphate fertilizer plant in the Republic of Zambia (hereinafter referred to as "the Study") in accordance with the laws and regulations in force in Japan.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the Study, in close cooperation with authorities concerned of the Government of Zambia.

The present document sets force the scope of work with regard to the Study.

II. The Objective of the Study

The objective of the Study is to investigate the technical and economic feasibility of the establishment of a fused magnesium phosphate fertilizer plant in Zambia with utilization of phosphate rock in Chilembwe and dolomite in Lusaka.

III. Scope of the Study

In order to achieve the above objectives, the Study will cover the following items:

1. Literature survey on the background of the Project
    - 1-1 To review worldwide supply & demand and price movement of fertilizers
    - 1-2 To review present situation of and policy on agriculture in Zambia
    - 1-3 To review present situation of and policy on fertilizer in Zambia
        - (1) Fertilizer industry
        - (2) Supply and demand of fertilizers

(3) Trend of consumption of fertilizers

1-4 To review the Pre-feasibility Study Report for the Phosphate Development Project provided by JICA in 1985

2. Study on the fertilizer market and its distribution system in Zambia

2-1 To review present and past supply and consumption of fertilizers

2-2 To investigate present and past prices of fertilizers

2-3 To review the cost and channel of transportation of fertilizers

2-4 To predict potential supply and demand of fertilizers in Zambia for coming ten years

2-5 To analyze present marketing and distribution system and to propose an appropriate marketing and distribution system for the Project

3. Study on the availability of utilities and raw materials for the Project

3-1 Electric power

3-2 Industrial water

3-3 Phosphate rock

3-4 Dolomite

3-5 Others

4. Study on the project site

4-1 To investigate the natural conditions of the site and its surrounding area

(1) Meteorology

(2) Geology and topography

4-2 To investigate the socio-economic conditions

(1) Regional population, labour force and wages, etc.

(2) Existing regional industries

(3) Regional development plan

4-3 To investigate utilities and infrastructure

K. M.

(1) Electric power

(2) Industrial Water

(3) Transportation (road and railway) and communication

4-4 To select the plant site based on the raw materials, utilities, infrastructure, and on the distribution of products

5. Preparation of the basic plan and the conceptional design of a fertilizer plant

5-1 To determine the optimum production scale

5-1 To determine condition for the design of the proposed fertilizer plant

5-2 To prepare conceptional design

5-3 To propose transportation plan of equipment and materials for plant construction

5-4 To prepare implementation program of plant construction

5-5 To propose organization and manpower plan for plant construction

5-6 To prepare operation program on the commercial basis

5-7 To propose operation and management organization

6. Estimation of construction cost of the proposed fertilizer plant

6-1 To estimate construction cost of the process plants

6-2 To estimate construction cost of the utility and off-site facilities

7. Financial analysis

7-1 Capital requirements

(1) Fixed capital

(2) Working capital

(3) Investment schedule

7-2 Procurement of capital

7-3 Production cost

7-4 Projected balance sheet

7-5 Projected income statement

7-6 To estimate financial internal rate of return

7-7 To estimate degree of sensitivity to the following variables:

(1) Investment cost

(2) Price of raw materials

(3) Selling price

(4) Interest rate

8. Economic and social evaluation

9. Conclusion and recommendations

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IV. Steps and Schedule of the Study

1. Steps

Step 1: Preparatory work in Japan

Step 2: Field work in Zambia

Step 3: Home office work in Japan

Step 4: Presentation of and discussion on the Draft Final Report

2. Schedule

Schedule of the Study is shown in Annex .

V. Reports

JICA shall prepare and submit the following reports written in English to the Government of Zambia within the time periods indicated below:

1. Progress Report at the end of the Step 2: 10 copies

2. Draft Final Report and its summary within 6.5 (six and a half) months after the commencement of the Step 2: 15 copies

3. Final Report and its summary within 2.5 (two and a half) months after the receipt of comments on the Draft Final Report from the Government of Zambia: 30 copies

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VI. Undertaking of the Government of Zambia

1. To facilitate the smooth implementation of the Study, the Government of Zambia shall take necessary measures:

   1-1 To secure the safety of the Japanese study team (hereinafter referred to as "the Team")

   1-2 To permit the members of the Team to enter, leave and sojourn in Zambia for the duration of their assignment therein, and exempt them from alien registration requirements

   1-3 To exempt the members of the Team from taxes, duties and other charges on equipment, machinery and other materials brought into Zambia for the implementation of the Study

   1-4 To exempt the members of the Team from income taxes and other charges of any kinds imposed on or in connection with any emoluments or allowances paid to the members of the Team for their services in connection with the implementation of the Study

   1-5 To provide the necessary facilities to the Team for the remittance as well as utilizations of fund introduced in Zambia from Japan in connection with the implementation of the Study

   1-6 To provide medical services as needed and its expenses will be chargeable on the members of the Team

   1-7 To secure permission for entry into private properties or restricted areas for the conduct of the Study

   1-8 To secure permission to take all data and documents related to the Study(including photographs) out of Zambia to Japan by the Team

2. The Government of Zambia shall bear claims, if any arises against the members of the Team resulting from, occurring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or willful misconduct on the part of the Japanese members of the Team.

3. INDECO LTD. shall act as counterpart agency to the Team and also as coordinating body in

K. M.

relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

4. INDECO LTD. shall, at its own expense, provide the Team with the following, in cooperation with other relevant organization:

4-1 Available data and information related to the Study

4-2 Counterpart personnel

4-3 Suitable office space with necessary equipment

4-4 Identification cards

VII. Undertaking of JICA

For the implementation of the Study, JICA shall take the following measures:

1. To dispatch, at its own expense, the Team to Zambia

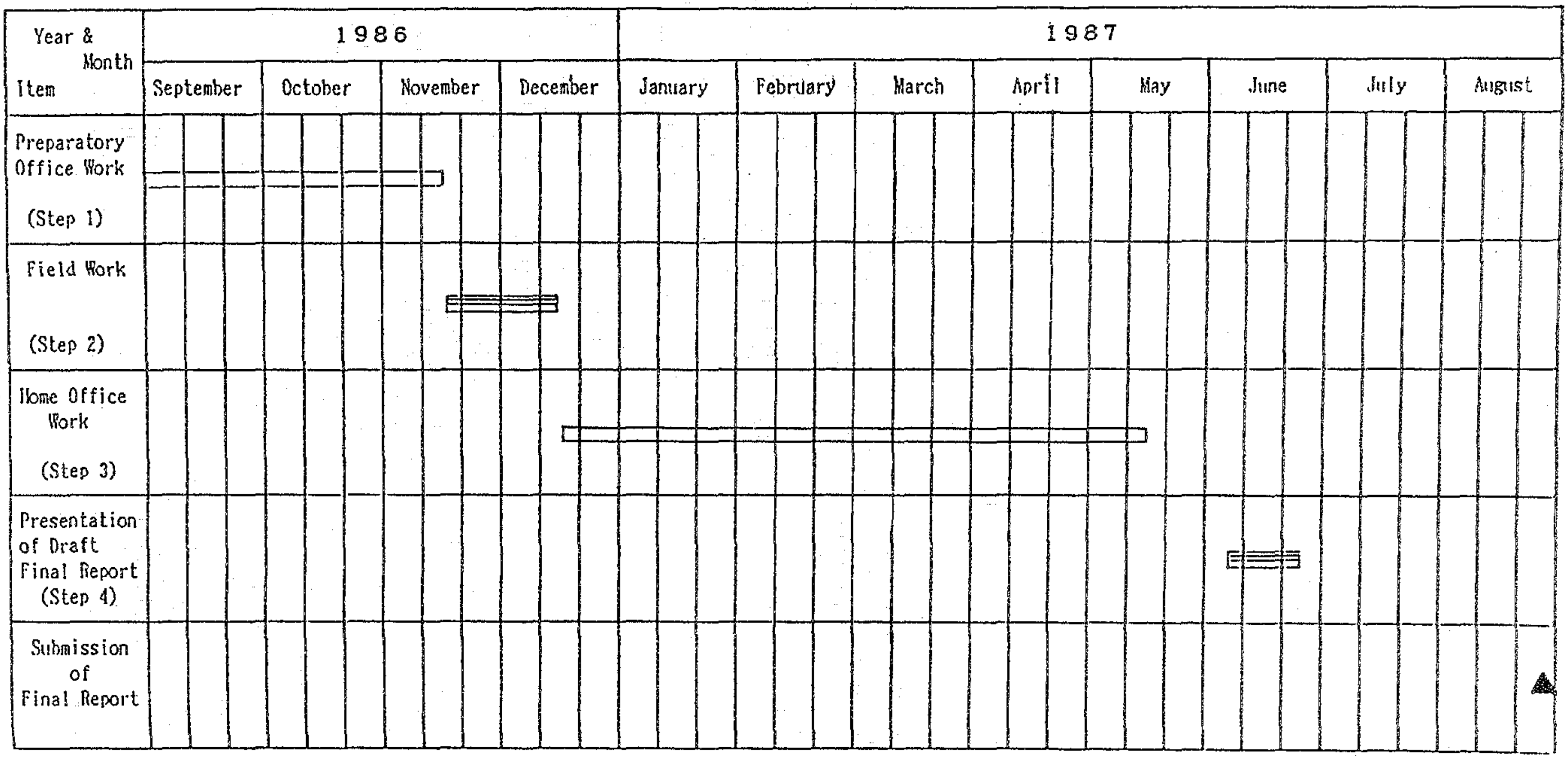
2. To pursue technology transfer to Zambian counterpart personnel in the course of the Study

VIII. Consultation

JICA and INDECO LTD. shall consult with each other in respect of any matter that may arise in the interpretation of implementation of the present arrangement.

<Annex>

Tentative Schedule of the Study



In Japan ▭ In the Republic of Zambia ▤

Annex I-2

MEMBERS OF STUDY TEAM OF JICA

	Name in Full	Speciality Field	Major Assignments for the Study
1.	Dr. Shigeo UEKI	Techno-Economist, Agriculture and Chemical Industries	Leader of the Study Team
2.	Mr. Hiroshi SAKO	Mechanical Engineer	Plant Design
3.	Mr. Makoto KUWABARA	Chemical Engineer	Sub-Leader, Technical Study and Fertilizer Production
4.	Mr. Tetsuo INOOKA	Agricultural Economy and Marketing	Fertilizer Market and Distribution
5.	Mr. Ryo KANTO	Soil and Agriculture	Soil, Agriculture and Farm Management
6.	Mr. Hiroshi MARUYAMA	Economist	Financial and Economic Analysis
7.	Mr. Takao GATANAGA	Electric Engineer	Utilities and Infrastructure
8.	Mr. Satoshi USUI	Mining Engineer	Raw Materials (Phosphate Rock and Others)
9.	Mr. Nobuaki KOTAKA	Fertilizer Production	Fused Magnesium Phosphate Production and Serpentine Supply

Field Survey Period: November 23, 1986 to December 22, 1986 in Zambia

Annex I-3

LIST OF MEMBERS OF COORDINATING BODY AND COUNTERPART AGENCY FOR THE STUDY IN ZAMBIA

INDECO LTD., Indeco House, Buteko Place, Lusaka

- P. O. Box 31935
- Tel. 214555
- Telex ZA 41821 Zambia

- Mr. Dixie Zulu, Managing Director
- Mr. Chisambwe M. Kapihya, Executive Director
- Mr. Stanley Kaweme Tamele, Technical Director
- Mr. F. Mwewa Kambobe*, Director of Project and Technical Service
- Mr. Winston Mutal*, Project Manager - Agronomist and Agricultural Economist
- Mr. G. Kimber, Manager-Engineering Services
- Mr. Tom G. Rukimirana, Project Officer
- Mrs. Sandi Maliselo, Project Officer
- Dr. B. S. Muzandu, Group Industrial Economist and Head, Economic Evaluation Unit
- Mr. S. R. Kodeswaran, Financial Analyst - Projects
- Mr. Simon Mwale, Public Relations Officer
- Mr. Ernsto Perez Escobar, UNIDO, INDECO
- Mr. B. M. Kusweje, Civil Engineer
- Mr. S. K. Seth, Group Mechanical Engineer
- Mr. R. M. Mitimingi, Project Officer

* Attended JICA Training Program in Japan from June 4 to June 24, 1987 and visited governmental, industrial and agronomical facilities throughout in Japan for research and training objectives.

Annex I-4 FIELD WORK SCHEDULE IN ZAMBIA (1/4)

Date in 1986	Weather*	Study Team Members: Dr. S. Ueki	H. Sako	M. Kuwabara	T. Inooka	R. Kanto	H. Maruyama	T. Gatanaga	S. Usui	N. Kotaka
		- Leader, Agriculture and Chemical Industries	- Plant Design	- Sub-Leader, Fertilizer Production	- Fertilizer Market and Distribution	- Soil, Agriculture and Farm Management	- Financial and Economic Analysis	- Utility and Infrastructure	- Phos Rock and Other Raw Materials	- Serpentine and FMP Production
November										
23, S	F	Tokyo, AF269 Paris	Tokyo, AF263 Paris	Tokyo, AF269 Paris	Tokyo, AF269 Paris	-	-	-	Tokyo, AF269 Paris	Tokyo, AF269 Paris
24, M	R	Paris, UT745	Paris, UT745	Paris, UT745	Paris, UT745	-	-	-	Paris, UT745	Paris, UT745
25, T	C	Lusaka, EOJ, JICA	Lusaka, EOJ, JICA	Lusaka, EOJ, JICA	Lusaka, EOJ, JICA	-	-	-	Lusaka, EOJ, JICA	Lusaka, EOJ, JICA
26, W	F	MINEX, INDECO	MINEX, INDECO	MINEX, INDECO	MINEX, INDECO	-	-	-	MINEX, INDECO	MINEX, INDECO
27, T	F	Chilembwe, Phos Rock	Chilembwe, Phos Rock	Chilembwe, Phos Rock	NAMBOARD, CFB	-	-	-	Chilembwe, Phos Rock	Chilembwe, Phos Rock
28, F	R	Chilembwe, Phos Rock Chitawe Dam, Mankwala Dam	Chilembwe, Phos Rock Chitawe Dam, Mankwala Dam	Chilembwe, Phos Rock Chitawe Dam, Mankwala Dam	JICA, MAWD, Mt. Makulu-CRS	-	-	-	Chelembwe, Phos Rock	Chilembwe, Phos Rock
29, S	F	Lusaka, Compile Report, JICA	Lusaka, Compile Report, JICA	Lusaska, Compile Report, JICA	Lusaka, Compile Report, JICA	-	-	-	Lusaka, Compile Report, JICA	Lusaka, Compile Report, JICA
30, S	F	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, Compile Report	Tokyo, AF269 Paris	Tokyo, AF269 Paris	Tokyo, AF269 Paris	Lusaka, Compile Report	Lusaka, Compile Report

Annex I-4 FIELD WORK SCHEDULE IN ZAMBIA (2/4)

Date in 1986	Weather*	Study Team Members: Dr. S. Ueki	H. Sako	M. Kuwabara	T. Inooka	R. Kanto	H. Maruyama	T. Gatanaga	S. Usui	N. Kotaka
December										
01, M	R	Mkushi, Serpentine, Muloba Ranch	Mkushi, Serpentine, Muloba Ranch	Mkushi, Serpentine, Muloba Ranch	NAMBOARD	Paris, UT745	Paris, UT745	Paris, UT745	Mkushi, Serpentine, Muloba Ranch	Mkushi, Serpentine, Muloba Ranch
02, T	F	ZR, MTZ, Kapiri Glass, Silica Sand	ZR, MTZ, Kapiri Glass, Silica Sand	ZR, MTZ, Kapiri Glass, Silica Sand	ZCF, AFC, MAWD	Lusaka, JICA	Lusaka, JICA	Lusaka, JICA	ZR, MTZ, Kapiri Glass, Silica Sand	ZR, MTZ, Kapiri Glass, Silica Sand
03, W	F	INDECO, ZCCM	INDECO, ZCCM, INDECO	INDECO, ZCCM, INDECO	INDECO, Mt. Makulu-CRS, CSO	INDECO , Mt. Makulu-CRS, CSO	INDECO	INDECO, ZCCM	INDECO, MINEX	INDECO, MINEX
04, T	F	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, NCZ	NCZ, MCZ
05, F	F	INDECO, EOJ, BOZ, DBZ	INDECO, EOJ, INDECO	INDECO, EOJ, BOZ, DBZ	LINTCO, EOJ, INDECO	LINTCO, EOJ, INDECO	INDECO, EOJ, BOZ, DBZ	INDECO, MAWD	INDECO, EOJ, MINEX, Dolomite	INDECO, EOJ, MINEX, Dolomite
06, S	F	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, Compile Report	Chongwe-CFA	Chongwe-CFA	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, Compile Report, MINEX	Lusaka, Compile Report, MINEX
07, S	R	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, Compile Report	Kabwe-CFA	Kabwe-CFA	Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, MINEX	Lusaka, MINEX
08, M	R	INDECO, NCZ	INDECO, NCZ	INDECO, MINEX, NCZ	Ndola-DAO, Bush-Fallow Ash - Cultures Farms	Ndola-DAO, Bush-Fallow Ash - Cultures Farms	INDECO, CSO, NCZ	INDECO, CSO, NCZ	INDECO, MINEX	INDECO, MINEX

Annex I-4 FIELD WORK SCHEDULE IN ZAMBIA (3/4)

Date in 1986	Weather*	Study Team Members: Dr. S. Ueki	H. Sako	M. Kuwabara	T. Inooka	R. Kanto	H. Maruyama	T. Gatanaga	S. Usui	N. Kotaka
December										
09, T	R	ZESCO, MAWD, DOE	ZESCO, JICA, Minestone	ZESCO, MAWD, DOE	Travel to Lusaka	Travel to Lusaka	ZESCO, MAWD, DOE	ZESCO, JICA, Minestone	MINEX, JICA, Minestone	MINEX, JICA, Minestone
10, W	R	MOF, EOJ, BOZ, MANICA	CSSL, EOJ, CHL, MANICA	MOF, EOJ, BOZ, MANICA	Mumbwa-DAO, Hoe-Plough -Cultures Farms	Mumbwa-DAO, Hoe-Plough -Cultures Farms	INDECO, LD, INDECO	INDECO, INDECO	CSSL, CHL, MANICA	CSSL, CHL, MANICA
11, T	R	MAWD, MCI, ZIMCO	INDECO, INDECO	MAWD, MCI, ZIMCO	Lusaka-DAO, State Farm	Lusaka-DAO, State Farm	INDECO, CSO, INDECO	INDECO, CSO, INDECO	INDECO, EOJ, Lusaka, BR308	INDECO, EOJ, Lusaka, BR308
12, F	R	ZSC, MCI, MCC-Party	Kabwe, ZR, KIFL, ZESCO	ZSC, MCI, MCC-Party, MANICA	MCC-Party, Choma-CFA	MCC-Party, Choma-CFA	MCC-Party CSO, INDECO,	Kabwe, ZR, KIFL, ZESCO	London, BA005	London, BA005
13, S	F	Lusaka, Compile Report	Lusaka, INDECO	Lusaka, INDECO	Kalomo-CFA Kalomo-DAO	Kalomo-CFA Kalomo-DAO	Lusaka, Compile Report	Lusaka, ZESCO	Tokyo	Tokyo
14, S	F	Lusaka, Compile Reprot	Lusaka, INDECO	Lusaka, INDECO	Travel to Lusaka, Compile Report	Travel to Lusaka, Compile Report	Lusaka, Compile Report	Lusaka, ZESCO	-	-
15, M	F	NAMBOARD, NCDP	ZESCO, TAZARA	ZESCO, UNZA, TAZARA, NCDP	NAMBOARD, INDECO	NAMBOARD, INDECO	INDECO, NCDP	ZESCO, MD, NCDP, ZESCO	-	-
16, T	F	MAWD, NCDP	NCZ, INDECO	MAWD, NCDP, UNZA	MAWD, NAMBOARD	MAWD, NAMBOARD	MAWD, NCDP	NCZ, INDECO	-	-

Annex I-4 FIELD WORK SCHEDULE IN ZAMBIA (4/4)

Date in 1986	Weather*	Study Team Members: Dr. S. Ueki	H. Sako	M. Kuwabara	T. Inooka	R. Kanto	H. Maruyama	T. Gatanaga	S. Usui	N. Kotaka
December										
17, W	F	MAWD, Mt. Makulu-CRS, INDECO, JICA, EOJ	CHL, MINEX, ZESCO, INDECO, JICA, EOJ	MAWD, Mt. Makulu-CRS, INDECO, JICA, EOJ	MAWD, Mt. Makulu-CRS, NAMBOARD, JICA, EOJ	MAWD, Mt. Makulu-CRS, NAMBOARD, JICA, EOJ	MAWD, Mt. Makulu-CRS, INDECO, JICA, EOJ	INDECO, ZESCO, INDECO, JICA, EOJ	-	-
18, T	F	INDECO, EOJ, MINEX	INDECO, MINEX, ZESCO	INDECO, EOJ, MINEX	INDECO, MAWD, NAMBOARD	INDECO, MAWD, Lusaka, BR312	INDECO, MAWD, Lusaska, BR308	INDECO, ZESCO, Lusaka, BR308	-	-
19, F	F	INDECO, ZCCM, EOJ, JICA, NAMBOARD, Progress Report, Minutes of Meeting	INDECO, ZCCM, EOJ, JICA, ZESCO, Progress Report, Minutes of Meeting	INDECO, ZCCM, EOJ, JICA, ZESCO, Progress Report, Minutes of Meeting	INDECO, INDECO, EOJ, JICA, NAMBOARD, Progress Report, Minutes of Meeting	London, BA005	London BA005	London BA005	-	-
20, S	F	President, State House, Lusaka, BR312	NCZ, President, State House, Lusaka, BR312	ZSC, Molasses, President, State House, Lusaka, BR312	NAMBOARD President, State House, Lusaka, BR312	Tokyo	Tokyo	-	-	-
21, S	F	London, BA005	London, BA005	London, BA005	London, BA005	-	-	-	-	-
22, M	F	Tokyo	Tokyo	Tokyo	Tokyo	-	-	-	-	-
23, T	F	-	-	-	-	-	-	-	-	-
24, W	F	Reporting at JICA, Submission of Progress Report and Minutes of Meeting	-	Reporting at JICA, Submission of Progress Report and Minutes of Meeting	-	-	-	-	-	-

* Weather at Noon: C = Cloudy, F = Fair, R = Rain, S = Snow

Annex I-5

INTERVIEWED PERSONS FOR THE STUDY IN ZAMBIA (1/4)

1. Ministry of Agriculture and Water Development (MAWD)

   - General K. Chinkuli (Rtd) M.P., Minister
   - Mr. C. Kalima, Senior Soil Surveyor - Land Evaluation
   - Mr. J. B. Mutelo, Acting Director of Agriculture
   - Mr. Imanga Kaliangile, Acting Chief-Agriculture Research Officer

2. Ministry of Finance (MOF)

   - Mr. B. M. Zimba, Under Secretary

3. Ministry of Commerce and Industry (MCI)

   - Mr. M. X. Mufwaya, Under Secretary

4. Department of Energy (DOE)

   - Mr. Collins D. Kanayuma, Electrical Engineer
   - Mr. Frank Heyes, Fosil Fuel Adviser

5. MINEX Dept., ZIMCO LTD., Exploration House, Government Road, Lusaka

   - Mr. A. S. Sliwa, Exploration Supervisor
   - Mr. G. R. Rao, Exploration Supervisor
   - Mr. Sandford Mambwe, Project Geologist

6. Zambia Consolidated Copper Mines Ltd. (ZCCM), Lusaka

   - Mr. Len Mabson, Director of Development
   - Dr. Peter V. Freeman, Consulting Geologist

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

   - Mr. Ronald Fogg, Managing Director
   - Ing. Polizzi Salvatore, General Manager
   - Mr. I. M. Liayo, Technical Manager

8. Zambia Industrial and Mining Corp., Ltd. (ZIMCO), Zimco House, Lusaka

   - Mr. Pethiyagoda, Technical Adviser (Petroleum Products)

INTERVIEWED PERSONS FOR THE STUDY IN ZAMBIA (2/4)

9. Zambia Bureau of Standards (ZBS)

   - Mr. M. M. Mukelabai, Standard Officer, Chemical Division

10. Bank of Zambia (BOZ), Lusaka

    - Mr. G. Mumba, Director, Balance Payments/International Economic Relations Division

11. Development Bank of Zambia (DBZ), Development House Lusaka

    - Mr. A. Muchanga, Director of Projects Appraisal

12. National Committee for Development Planning (NCDP)

    - Mr. S. D. Verma, Advisor-Macro Planning
    - Mr. G. J. Chivunga, Assistant Director (IP)
    - Mr. K. N. C. Chinjanga, Economist (SP)
    - Mr. R. Lichana, Director

13. Zambia Railways Ltd. (ZR), Kabwe

    - Mr. L. C. Nkonkomalimba, Director of Tariff and Marketing
    - Mr. George B. Mungaila, Assistant Marketing
    - Mr. M. C. Kuntawala, Chief Civil Engineer

14. Tanzania Zambia Railway Authority (TAZARA or TZR), Nsefu House, Lusaka

    - Mr. M. K. Sakala, Traffic Officer

15. Zambia Electricity Supply Corp., Ltd. (ZESCO), Grant East Road

    - Mr. Roy G. Miti, General Manager
    - Mr. K. A. J. Brooks, Chief Engineer - Distribution and Supply (South)
    - Mr. Labib F. Hanna, Senior Developing Engineer
    - Mr. G. Mwinanyambe, Engineering Services Manager

16. Meteorological Department of Zambia (MD)

    - Mr. M. R. Muchinda, Agrometeorologist

17. Mulungushi Textiles of (Z) Ltd. (MTZ), Kabwe

    - Mr. Borry M. Sumbwe, Assistant Production Manager

18. Kabwe Industrial Fabrics Ltd. (KIF), Kabwe

    - Mr. John Sikapite, Acting Works Engineer

INTERVIEWED PERSONS FOR THE STUDY IN ZAMBIA (3/4)

19. Kapiri Glass Products Ltd., Kabwe

    - Mr. Osborned Timu Sikazwe, Works Chemist

20. Muloba Ranch, Commercial Farmer, Mkushi

    - Mr. and Mrs. Zlatan Arnautovich
      Muloba Ranch, Mkushi,
      P. O. Box 810052, Kapiri Mposhi

21. The Zambia Sugar Company Ltd. (ZSC)

    - Mr. Norman L. Davies, Projects and Planning Manager
      (Tate & Lyle Technical Services Ltd., England)

22. African States Consulting Organization Zambia Ltd. (ASCO)

    - Mr. A. E. Mazzucchelli, Director

23. Kabwe Urban District Council

    - Mr. H. J. Kavimba, Development Secretary

24. Kabwe Industrial Fabrics Ltd.

    - Mr. J. Sikapite, Acting Works Engineer

25. Contract Haulage Ltd. (CHL)

    - Mr. A. S. Kapaya, Region Manager (South)
    - Mr. Sivarajah, Finance and Planning Manager

26. Crushed Stone Sales Ltd. (CSSL)

    - Mr. R. K. Kapoor, Chief Accountant

27. Minestone Ltd.

    - Mr. B. C. Patel, Chief Estimator
    - Mr. B. E. Mie, Chief Estimator

28. National Agriculture Marketing Board of Zambia (NAMBOARD)

    - Mr. M. A. Sichali, Grain Marketing Manager

29. Commercial Farmers Bureau (CFB)

    - Mr. John Hudson

INTERVIEWED PERSONS FOR THE STUDY IN ZAMBIA (4/4)

30. Mount Makulu Central Research Station (Mt. Makulu - CRS)

    - Mr. J. K. McPhillips

31. Zambia Co-operative Federation Ltd. (ZCF)

    - Mr. C. Kapya Ndalameta, Managing Director

32. Agricultural Finance Co., Ltd. (AFC)

    - Mr. Alex M. Mundia, General Manager and Chief Executive

33. Commercial Farmers Association (CFA)

    - Mr. B. Danckwerts, Chairman, Choma/Kalomo
    - Ms. P. Green, Secretary, Choma/Kalomo
    - Mr. Jules Staal, Chairman, Kabwe
    - Mr. Percy Godwin, Grain Committee, Kabwe

34. Manica Freight Services

    - Mr. Rae Mostert, Airfreight Manager

35. University of Zambia (UNZA)

    - Mr. Chiro Kodamaya, Researcher, School of Oriental and African Studies
    - Dr. Wilfred C. Lombe, School of Mines

* * * * * * *

36. The Central Committee (MCC), United National Independence Party (UNIP)

    - Mr. A. J. Soko, The Honarable Member of Central Committee, The Chairman, Economic and Finance Committee
    - Mr. Eusebius Chola Katai, The Private Secretary to the Chairman, Economic and Finance Committee

37. Embassy of Japan, Haile Selassie Avenue, Lusaka

    - H.E. Masatoshi Ohta, Ambassador
    - Mr. Yoshinori Imagawa, Counseller
    - Mr. Yukio Kitamura, Second Secretary
    - Mr. Kyohei Ishida, Second Secretary

38. Japan International Cooperation Agency (JICA), Manshila Road, Lusaka

    - Mr. Hiroji Yamaguchi, Representative
    - Mr. Hiroaki Oshiba, Coordinator
    - Mr. D. K. Mapani, Administrative Officer

Annex II-1

FERTILIZER STATISTICS IN ZAMBIA

LIST OF TABLES

Table AII-1-1 FERTILIZER PRODUCTION AND SALES BY NCZ

(Unit: ton)

Year*1	Nitrogen Fertilizer			Compound Fertilizer											
	Ammonium Nitrate			"C"			"D"			"R"			"X"		
	Prod.	Sales		Prod.	Sales		Prod.	Sales		Prod.	Sales		Prod.	Sales	
		A	B		A	B		A	B		A	B		A	B
1970/71	3,468	5,611		-	-		-	-		-	-		-	-	
1971/72	24,788	21,771		-	-		-	-		-	-		-	-	
1972/73	16,473	20,313		-	-		-	-		-	-		-	-	
1973/74	12,467	15,000		-	-		-	-		-	-		-	-	
1974/75	21,776	19,321		-	-		-	-		-	-		-	-	
1975/76	17,051	18,702		-	-		-	-		-	-		-	-	
1976/77	22,838	21,309		-	-		-	-		-	-		-	-	
1977/78	23,344	2,416		-	-		-	-		-	-		-	-	
1978/79	29,544	28,422		-	-		-	-		-	-		-	-	
1979/80	26,303	27,305		-	-		-	-		-	-		-	-	
1980/81	14,658	14,915	18,882	-	-	-	-	-	-	-	-	-	-	-	-
1981/82	15,411	14,602	14,154	-	-	-	3,659	1,829	-	5,620	5,545	3,591	2,038	2,056	2,056
1982/83	25,326	25,326	25,637	3,760	-	-	18,104	19,933	21,762	19,239	11,920	12,110	3,312	-	-
1983/84	18,389	18,073	17,621	-	2,842	2,750	-	-	-	-	7,837	9,610	60,520	60,655	40,146
1984/85	8,770	8,515	8,580	-	-	-	-	-	-	27,813	27,600	18,637	33,916	36,863	49,582
1985/86*2	15,905	12,969	6,481	-	-	-	21,837	20,775	-	6,326	10,129	9,592	29,643	27,878	3,887

Note: *1 April through March. (Sales A)
*2 1985/86 data covers April 1985 to December 1986.
Data does not include recycled fertilizers.
"Sales B" means the sales in calender year (1980/81 refers to 1980 calender year).

Source: NCZ

Table AII-1-2 IMPORTS OF FERTILIZER BY GRADE OF PRODUCT IN ZAMBIA, 1980-1985

(Unit: ton)

		1980	1981	1982	1983	1984	1985
End Products *1	Compound						
	D	20,751	45,000	-	40,000	74,480	-
	C	5,000	6,000	-	3,000	-	-
	V	-	-	-	3,000	-	-
	Urea	66,908	31,000	60,000	86,300	95,678	30,456
	CAN	-	-	-	-	25,000	-
	SSP	-	-	-	500	-	-
	Sodium Nit.	-	-	-	100	-	-
	End Prod. Total	92,659	82,000	60,000	132,900	195,158	30,456
	Total in Nutrient						
	N	33,153	19,120	27,600	44,016	57,960	14,010
	P205	4,550	9,480	-	8,870	14,896	-
	K20	2,675	5,220	-	4,810	7,448	-
Raw Materials *2	DAP	--	--	--	15,000	15,592	-
	TSP	--	--	--	10,500	4,042	-
	SOP	--	--	--	N.A.	3,465	-
	MOP	--	--	--	N.A.	-	-
	Raw Mate. Total	--	--	--	25,500	23,099	-
	Total in Nutrient						
	N	--	--	--	2,700	2,807	-
	P205	--	--	--	11,730	9,032	-
	K20	--	--	--	-	1,733	-
Total	Ton of Product	--	--	--	158,400	218,257	30,456
	Total in Nutrient						
	N	--	--	--	46,716	60,767	14,010
	P205	--	--	--	20,600	23,928	-
	K20	--	--	--	4,810	9,181	-

Note: - Nil
-- Not Available

Sources: *1 NAMBOARD
*2 NCZ

Table AII-1-3 CONSUMPTION OF FERTILIZER BY GRADE OF PRODUCT IN ZAMBIA, 1972-1985

(Unit: ton)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
COMPOUND														
A	-	-	-	115	-	303	476	151	58	4	18	6	6	-
C	5,872	4,679	6,326	8,389	3,228	539	5,988	4,298	5,429	6,079	4,164	2,317	2,498	4,092
V	-	-	-	3,732	563	4,117	3,617	1,282	1,509	2,308	1,426	748	1,293	1,193
R	-	-	-	17,483	21,909	23,472	16,709	26,448	38,977	41,811	31,762	17,378	18,648	22,260
X	60,618	46,042	42,076	20,360	22,161	30,121	20,166	19,952	35,534	29,853	37,930	28,761	34,440	26,983
D	-	-	-	24,705	30,411	31,673	30,184	28,005	28,921	35,923	53,366	43,396	21,689	57,518
12.24.12	-	-	-	-	-	-	-	-	-	-	-	-	724	214
STRAIGHT N														
Ammo. Nit.	-	-	-	17,793	17,284	25,339	20,292	17,842	24,317	26,458	21,142	16,265	11,912	9,375
Ammo. Sulf.	44,980	32,554	50,846	6,412	715	2,197	2,030	870	1,294	1,899	2,303	261	116	972
Urea	-	-	-	32,043	46,780	47,713	27,536	42,402	57,171	64,793	58,764	52,627	44,425	76,335
Sodium Nit.	-	-	-	708	708	254	563	156	167	297	30	21	17	69
CAN	-	-	-	-	-	-	-	-	-	-	-	-	1,907	4,786
STRAIGHT P														
SSP	-	-	-	1,086	751	130	308	137	517	286	99	151	131	155
TSP	498	280	351	386	1,325	1,480	1,588	1,588	2,051	1,919	622	667	336	749
Mixed SSP/TSP	-	-	-	-	-	-	-	-	-	12	86	627	0	156
STRAIGHT K														
SOP	832	1,226	2,751	316	1	35	62	62	78	185	64	61	167	80
MOP	-	-	-	11	38	134	87	140	141	105	44	110	47	64
OTHERS														
Lime Mixture	-	-	-	-	-	-	-	-	0	0	0	0	441	126
Gypsum & Others	-	-	-	156	4,900	-	471	2,035	197	6,859	6,008	2,403	5,096	6,053
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 AII-1-4 CONSUMPTION OF FERTILIZER BY GRADE BY PROVINCE IN ZAMBIA, 1982

(Unit: ton)

	Southern	Lusaka	Copper-belt	Central	North-western	Eastern	Western	Luapula	Northern	Total
COMPOUND										
A	-	-	-	18	-	-	-	-	-	18
C	1,582	797	62	1,474	-	219	2	1	27	4,164
V	626	225	182	354	3	36	-	-	-	1,426
R	30,275	1,166	87	73	-	-	143	-	18	31,762
X	174	6,473	1,436	14,568	177	11,152	173	40	3,737	37,930
D	3,988	11,291	2,232	12,605	854	11,170	190	816	10,220	53,366
12.42.12	-	-	-	-	-	-	-	-	-	-
STRAIGHT N										
Ammo. Nit.	3,553	5,584	1,863	3,885	1,162	1,465	224	489	2,917	21,142
Ammo. Sulf.	846	137	46	1,190	11	45	14	14	-	2,303
Urea	17,747	7,895	1,021	18,229	20	9,920	112	-	3,820	58,764
Sodium Nit.	1	4	5	3	-	17	-	-	-	30
CAN	-	-	-	-	-	-	-	-	-	-
STRAIGHT P										
SSP	7	71	-	-	1	20	-	-	-	99
TSP	159	83	189	36	-	188	-	7	-	662
Mixed SSP/TSP	-	-	-	-	-	-	-	-	-	-
STRAIGHT K										
SOP	16	29	5	1	1	-	-	12	-	64
MOP	1	32	6	-	-	-	-	5	-	44
OTHERS *1	2,323	2,390	8	612	46	707	8	-	-	6,094
Total	61,298	36,177	7,142	53,048	2,275	34,939	866	1,384	20,739	217,868
Total in Nutrient										
N	16,177	8,302	1,662	14,268	532	8,441	215	262	4,538	54,396
P205	7,184	3,294	732	4,195	190	3,463	84	170	2,424	21,731
K20	701	1,617	336	2,223	95	1,706	28	93	1,212	8,008

Source: NAMBOARD
Note: *1 Including 86 tons of mixed SSP/TSP.

Table AII-1-5 CONSUMPTION OF FERTILIZER BY GRADE BY PROVINCE IN ZAMBIA, 1983

(Unit: ton)

	Southern	Lusaka	Copper-belt	Central	North-western	Eastern	Western	Luapula	Northern	Total
COMPOUND										
A	-	-	-	6	-	-	-	-	-	6
C	85	896	287	524	-	477	7	-	41	2,317
V	318	247	44	134	-	4	1	-	-	748
R	17,009	290	2	27	-	47	2	-	1	17,378
X	3	3,083	996	7,547	796	4,433	409	181	11,313	28,761
D	2,926	5,681	1,909	13,052	214	15,429	606	1,552	2,027	43,396
12.42.12	-	-	-	-	-	-	-	-	-	-
STRAIGHT N										
Ammo. Nit.	1,336	2,116	1,002	2,155	1,079	2,975	405	721	4,476	16,265
Ammo. Sulf.	-	76	4	51	-	-	13	2	115	261
Urea	14,337	5,269	1,061	12,839	18	17,421	479	1	1,202	52,627
Sodium Nit.	2	11	5	3	-	-	-	-	-	21
CAN	-	-	-	-	-	-	-	-	-	-
STRAIGHT P										
SSP	-	100	33	-	18	-	-	-	-	151
TSP	552	109	-	5	-	-	-	-	-	666
Mixed SSP/TSP	-	-	-	-	-	-	-	-	-	-
STRAIGHT K										
SOP	2	51	7	1	-	-	-	-	-	61
MOP	-	100	9	-	-	1	-	-	-	110
OTHERS *1	389	713	273	1,368	1	272	-	1	13	3,030
Total	36,959	18,742	5,632	37,712	2,126	41,059	1,922	2,458	19,188	165,798
Total in Nutrient										
N	10,770	4,479	1,245	9,516	560	11,508	506	440	4,589	43,616
P205	4,305	1,686	519	3,439	126	3,577	163	328	1,539	15,799
K20	352	953	291	1,767	61	1,824	82	164	774	6,265

Source: NAMBOARD
Note: *1 Including 627 tons of mixed SSP/TSP.

Table AII-1-6 CONSUMPTION OF FERTILIZER BY GRADE BY PROVINCE IN ZAMBIA, 1984

(Unit: ton)

	Southern	Lusaka	Copper-belt	Central	North-western	Eastern	Western	Luapula	Northern	Total
COMPOUND										
A	-	-	-	6	-	-	-	-	-	6
C	329	987	87	732	-	363	-	-	-	2,498
V	573	298	87	335	-	-	-	-	-	1,293
R	18,319	274	-	15	-	39	1	-	-	18,648
X	1	1,107	1,136	9,286	163	9,897	690	103	12,057	34,440
D	1,359	4,634	2,685	9,849	85	1,011	343	1,420	303	21,689
12.24.12	-	-	1	-	-	-	-	-	723	724
STRAIGHT N										
Ammo. Nit.	78	881	1,766	1,257	568	981	438	708	5,234	11,912
Ammo. Sulf.	1	62	7	14	-	-	-	33	-	116
Urea	16,953	2,683	1,581	13,604	2	8,781	594	134	93	44,425
Sodium Nit.	-	-	-	16	1	-	-	-	-	17
CAN	-	-	-	-	-	-	-	-	1,907	1,907
STRAIGHT P										
SSP	1	128	3	-	-	-	-	-	-	131
TSP	1	272	49	1	-	2	-	-	10	336
Mixed SSP/TSP	-	-	-	-	-	-	-	-	-	-
STRAIGHT K										
SOP	18	143	3	3	-	-	-	-	-	167
MOP	-	36	9	-	-	2	-	-	-	47
OTHERS	332	1,919	322	1,469	50	810	4	31	601	5,537
Total	37,965	13,424	7,736	36,587	869	21,886	2,070	2,429	20,928	143,894
Total in Nutrient										
N	11,668	2,361	1,841	9,600	239	6,487	596	476	4,873	38,144
P205	4,065	1,374	698	3,022	33	1,230	138	294	1,446	12,298
K20	270	775	356	1,590	17	641	69	147	720	4,585

Source: NAMBOARD

Table AII-1-7 CONSUMPTION OF FERTILIZER BY GRADE BY PROVINCE IN ZAMBIA, 1985

(Unit: ton)

	Southern	Lusaka	Copper-belt	Central	North-western	Eastern	Western	Luapula	Northern	Total
COMPOUND										
A	-	-	-	-	-	-	-	-	-	-
C	410	1,269	365	1,059	5	983	1	-	-	4,092
V	479	335	62	314	-	-	2	1	-	1,193
R	21,318	379	-	493	-	59	1	-	10	22,260
X	138	758	1,273	10,579	990	7,853	1,427	266	3,699	26,983
D	4,531	5,728	3,758	14,684	616	20,335	1,210	1,424	5,232	57,518
12.24.12	-	8	-	206	-	-	-	-	-	214
STRAIGHT N										
Ammo. Nit.	60	1,367	2,450	329	767	1,157	883	1,860	502	9,375
Ammo. Sulf.	-	968	-	4	-	-	-	-	-	972
Urea	18,292	4,874	2,622	23,421	14	24,148	682	273	2,009	76,335
Sodium Nit.	37	12	9	7	4	-	-	-	-	69
CAN	286	155	-	613	-	-	-	-	3,732	4,786
STRAIGHT P										
SSP	-	153	-	-	2	-	-	-	-	155
TSP	356	243	120	-	-	20	-	6	4	749
Mixed SSP/TSP	-	155	1	-	-	-	-	-	-	156
STRAIGHT K										
SOP	-	58	22	-	-	-	-	-	-	80
MOP	-	48	14	-	-	2	-	-	-	64
OTHERS										
Gypsum & Others	1,216	1,994	286	1,201	24	533	34	19	872	6,179
Total	47,123	18,504	10,982	52,910	2,422	55,090	4,240	3,849	16,060	211,180
Total in Nutrient										
N	13,304	3,850	2,708	14,834	532	15,183	1,025	963	3,332	55,729
P2O5	5,467	1,630	974	4,285	222	4,952	385	315	1,420	19,647
K2O	581	872	512	2,196	113	2,546	192	155	708	7,876

Source: NAMBOARD

Table AII-1-8 SHIPMENT OF FERTILIZER BY GRADE AND BY BRANCHES OF NAMBOARD, 1986

(Unit: ton)

	L/Stone	Monze	Lusaka Main	Ndola	Kitwe	Chisamba	Kabwe	Solwezi	Chipata	Mongu	Mansa	Kasama	Total
COMPOUND													
A	-	-	-	-	-	-	0	-	-	-	-	-	0
C	83	649	692	578	-	352	604	-	206	88	4	-	3,256
V	29	439	177	36	9	53	88	-	45	0	2	-	879
R	1,856	10,407	54	-	-	42	-	-	0	0	-	0	12,361
X	161	1,415	2,164	1,976	341	1,519	10,111	524	982	592	165	7,448	27,398
D	747	6,423	5,034	1,723	590	903	6,409	260	7,026	803	961	3,142	34,021
12.24.12	-	-	1	-	-	-	48	-	-	-	-	-	49
STRAIGHT N													
Ammo. Nit.	23	103	1,505	205	423	422	491	360	308	1,002	4,683	343	9,869
Ammo. Sulf.	-	0	-	-	-	-	67	-	-	-	-	-	67
Urea	1,317	16,013	3,946	2,062	739	2,683	15,936	392	11,461	729	239	6,764	62,282
Sodium Nit.	-	29	23	4	-	-	7	-	-	-	-	-	63
CAN	299	202	452	-	-	-	601	-	-	-	-	79	1,633
STRAIGHT P													
TSP	-	687	742	18	30	-	-	-	33	-	1	-	1,511
SSP	-	-	372	-	-	-	-	6	-	-	-	-	378
Mixed SSP/TSP	-	-	-	-	-	-	-	-	-	-	-	-	-
STRAIGHT K													
SOP	-	-	-	3	4	-	-	-	-	-	1	-	8
MOP	-	-	-	0	-	-	-	-	3	-	19	-	22
OTHERS													
Gypsum & Others	-	-	12	-	0	-	-	3	-	-	-	22	37
Total	4,517	36,369	15,173	6,605	2,137	5,974	34,363	1,546	20,065	3,215	6,073	17,798	153,833
Total in Nutrient	1,176	10,523	3,452	1,624	613	1,805	10,380	435	6,291	884	1,855	5,054	44,095
N	548	3,955	1,729	603	168	379	2,369	105	1,542	227	209	1,373	13,209
P205	97	857	721	347	79	216	1,238	52	786	121	116	686	5,318
K20	1,821	15,335	5,902	2,574	860	2,400	13,987	592	8,619	1,232	2,180	7,113	62,622

Source: NAMBOARD

Table AII-1-9 CONSUMPTION OF FERTILIZER BY GRADE IN SOUTHERN PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	1,582	85	329	410
V	626	318	573	479
R	30,275	17,009	18,319	21,318
X	174	3	1	138
D	3,988	2,926	1,359	4,531
12.42.12	-	-	-	-
STRAIGHT N				
Ammo. Nit.	3,553	1,336	78	60
Ammo. Sulf.	846	-	1	-
Urea	17,747	14,337	16,953	18,292
Sodium Nit.	1	2	-	37
CAN	-	-	-	286
STRAIGHT P				
SSP	7	-	1	-
TSP	159	552	1	356
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	16	2	18	-
MOP	1	-	-	-
OTHERS	2,323	389	332	1,216
Total	61,298	36,959	37,965	47,123
Total in Nutrient				
N	16,177	10,770	11,668	13,304
P205	7,184	4,305	4,065	5,467
K20	701	352	270	581

Source: NAMBOARD

Table AII-1-10 CONSUMPTION OF FERTILIZER BY GRADE IN LUSAKA PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	797	896	987	1,269
V	225	247	298	335
R	1,166	290	274	379
X	6,473	3,083	1,107	758
D	11,291	5,681	4,634	5,728
12.42.12	-	-	-	8
STRAIGHT N				
Ammo. Nit.	5,584	2,116	881	1,367
Ammo. Sulf.	137	76	62	968
Urea	7,895	5,269	2,683	4,874
Sodium Nit.	4	11	-	12
CAN	-	-	-	155
STRAIGHT P				
SSP	71	100	128	153
TSP	83	109	272	243
Mixed SSP/TSP	-	-	-	155
STRAIGHT K				
SOP	29	51	143	58
MOP	32	100	36	48
OTHERS	2,390	713	1,919	1,994
Total	36,177	18,742	13,424	18,504
Total in Nutrient				
N	8,302	4,479	2,361	3,850
P205	3,294	1,686	1,374	1,630
K20	1,617	953	775	872

Source: NAMBOARD

Table AII-1-11 CONSUMPTION OF FERTILIZER BY GRADE IN COPPERBELT PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	62	287	87	365
V	182	44	87	62
R	87	2	-	-
X	1,436	996	1,136	1,273
D	2,232	1,909	2,685	3,758
12.42.12	-	-	1	-
STRAIGHT N				
Ammo. Nit.	1,863	1,002	1,766	2,450
Ammo. Sulf.	46	4	7	-
Urea	1,021	1,061	1,581	2,622
Sodium Nit.	5	5	-	9
CAN	-	-	-	-
STRAIGHT P				
SSP	-	33	3	-
TSP	189	-	49	120
Mixed SSP/TSP	-	-	-	1
STRAIGHT K				
SOP	5	7	3	22
MOP	6	9	9	14
OTHERS	8	273	322	286
Total	7,142	5,632	7,736	10,982
Total in Nutrient				
N	1,662	1,245	1,841	2,708
P205	732	519	698	974
K20	336	291	356	512

Source: NAMBOARD

Table AII-1-12 CONSUMPTION OF FERTILIZER BY GRADE IN CENTRAL PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	18	6	6	-
C	1,474	524	732	1,059
V	354	134	335	314
R	73	27	15	493
X	14,568	7,547	9,286	10,579
D	12,605	13,052	9,849	14,684
12.42.12	-	-	-	206
STRAIGHT N				
Ammo. Nit.	3,885	2,155	1,257	329
Ammo. Sulf.	1,190	51	14	4
Urea	18,229	12,839	13,604	23,421
Sodium Nit.	3	3	16	7
CAN	-	-	-	613
STRAIGHT P				
SSP	-	-	-	-
TSP	36	5	1	-
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	1	1	3	-
MOP	-	-	-	-
OTHERS	612	1,368	1,469	1,201
Total	53,048	37,712	36,587	52,910
Total in Nutrient				
N	14,268	9,516	9,600	14,834
P205	4,195	3,439	3,022	4,285
K20	2,223	1,767	1,590	2,196

Source: NAMBOARD

Table AII-1-13 CONSUMPTION OF FERTILIZER BY GRADE IN NORTHWESTERN PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	-	-	-	5
V	3	-	-	-
R	-	-	-	-
X	177	796	163	990
D	854	214	85	616
12.42.12	-	-	-	-
STRAIGHT N				
Ammo. Nit.	1,162	1,079	568	767
Ammo. Sulf.	11	-	-	-
Urea	20	18	2	14
Sodium Nit.	-	-	1	4
CAN	-	-	-	-
STRAIGHT P				
SSP	1	18	-	2
TSP	-	-	-	-
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	1	-	-	-
MOP	-	-	-	-
OTHERS	46	1	50	24
Total	2,275	2,126	869	2,422
Total in Nutrient				
N	532	560	239	532
P205	190	126	33	222
K20	95	61	17	113

Source: NAMBOARD

Table AII-1-14 CONSUMPTION OF FERTILIZER BY GRADE IN EASTERN PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	219	477	363	983
V	36	4	-	-
R	-	47	39	59
X	11,152	4,433	9,897	7,853
D	11,170	15,429	1,011	20,335
12.42.12	-	-	-	-
STRAIGHT N				
Ammo. Nit.	1,465	2,975	981	1,157
Ammo. Sulf.	45	-	-	-
Urea	9,920	17,421	8,781	24,148
Sodium Nit.	17	-	-	-
CAN	-	-	-	-
STRAIGHT P				
SSP	20	-	-	-
TSP	188	-	2	20
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	-	-	-	-
MOP	-	1	2	2
OTHERS	707	272	810	533
Total	34,939	41,059	21,886	55,090
Total in Nutrient				
N	8,441	11,508	6,487	15,183
P205	3,463	3,577	1,230	4,952
K20	1,706	1,824	641	2,546

Source: NAMBOARD

Table AII-1-15 CONSUMPTION OF FERTILIZER BY GRADE IN WESTERN PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	2	7	-	1
V	-	1	-	2
R	143	2	1	1
X	173	409	690	1,427
D	190	606	343	1,210
12.42.12	-	-	-	-
STRAIGHT N				
Ammo. Nit.	224	405	438	883
Ammo. Sulf.	14	13	-	-
Urea	112	479	594	682
Sodium Nit.	-	-	-	-
CAN	-	-	-	-
STRAIGHT P				
SSP	-	-	-	-
TSP	-	-	-	-
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	-	-	-	-
MOP	-	-	-	-
OTHERS	8	-	4	34
Total	866	1,922	2,070	4,240
Total in Nutrient				
N	215	506	596	1,025
P2O5	84	163	138	385
K2O	28	82	69	192

Source: NAMBOARD

Table AII-1-16 CONSUMPTION OF FERTILIZER BY GRADE IN LUAPULA PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	1	-	-	-
V	-	-	-	1
R	-	-	-	-
X	40	181	103	266
D	816	1,552	1,420	1,424
12.42.12	-	-	-	-
STRAIGHT N				
Ammo. Nit.	489	721	708	1,860
Ammo. Sulf.	14	2	33	-
Urea	-	1	134	273
Sodium Nit.	-	-	-	-
CAN	-	-	-	-
STRAIGHT P				
SSP	-	-	-	-
TSP	7	-	-	6
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	12	-	-	-
MOP	5	-	-	-
OTHERS	-	1	31	19
Total	1,384	2,458	2,429	3,849
Total in Nutrient				
N	262	440	476	963
P205	170	328	294	315
K20	93	164	147	155

Source: NAMBOARD

Table AII-1-17 CONSUMPTION OF FERTILIZER BY GRADE IN NORTHERN PROVINCE, 1982-1985

(Unit: ton)

	1982	1983	1984	1985
COMPOUND				
A	-	-	-	-
C	27	41	-	-
V	-	-	-	-
R	18	1	-	10
X	3,737	11,313	12,057	3,699
D	10,220	2,027	303	5,232
12.42.12	-	-	723	-
STRAIGHT N				
Ammo. Nit.	2,917	4,476	5,234	502
Ammo. Sulf.	-	115	-	-
Urea	3,820	1,202	93	2,009
Sodium Nit.	-	-	-	-
CAN	-	-	1,907	3,732
STRAIGHT P				
SSP	-	-	-	-
TSP	-	-	10	4
Mixed SSP/TSP	-	-	-	-
STRAIGHT K				
SOP	-	-	-	-
MOP	-	-	-	-
OTHERS	-	13	601	872
Total	20,739	19,188	20,928	16,060
Total in Nutrient				
N	4,538	4,589	4,873	3,332
P205	2,424	1,539	1,446	1,420
K20	1,212	774	720	708

Source: NAMBOARD

Table AII-1-18 MONTHLY SHIPMENT OF FERTILIZER BY GRADE IN ZAMBIA, 1983

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
COMPOUND													
A	-	-	-	-	0	-	0	1	1	2	1	1	6
C	85	38	340	414	84	48	3	204	309	254	366	172	2,317
V	47	34	20	37	5	5	13	24	122	33	67	341	748
R	63	26	42	1,806	16	3	949	1,944	3,180	3,714	3,401	3,033	17,378
X	231	213	109	25	31	109	1,006	2,304	5,706	6,247	8,676	4,104	28,761
D	4,090	515	647	393	248	261	344	2,418	6,196	9,868	12,876	5,540	43,396
12.24.12	-	-	-	-	-	-	-	-	-	-	-	-	-
STRAIGHT N													
Ammo. Nit.	3,852	1,445	67	20	352	38	1,607	160	860	2,107	2,183	3,574	16,265
Ammo. Sulf.	27	24	12	15	11	15	2	7	134	2	5	4	261
Urea	6,511	5,833	1,254	708	264	346	54	285	3,962	10,379	18,493	4,536	52,627
Sodium Nit.	7	2	1	1	0	0	0	4	2	2	1	1	21
CAN	-	-	-	-	-	-	-	-	-	-	-	-	-
STRAIGHT P													
SSP	21	1	15	9	12	2	5	7	6	2	39	34	151
TSP	5	1	0	0	0	0	1	0	2	86	521	50	667
Mixed SSP/TSP	126	0	-	500	-	-	-	-	-	-	-	0	627
STRAIGHT K													
SOP	0	0	3	5	0	1	1	0	25	17	5	3	61
MOP	8	3	3	0	5	2	1	3	2	6	74	3	110
OTHERS													
Gypsum	1	-	0	-	-	-	0	-	-	-	3	138	141
Sub Std. Fert.	239	188	13	34	15	44	54	36	199	497	457	525	2,262
Lime Mixture	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	15,312	8,325	2,523	3,168	1,045	876	4,041	7,398	20,666	33,216	47,158	22,059	165,798

Source: NAMBOARD

Table AII-1-19 MONTHLY SHIPMENT OF FERTILIZER BY GRADE IN ZAMBIA, 1984

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
COMPOUND													
A	1	1	1	1	1	1	-	-	-	-	-	-	6
C	33	361	134	205	518	46	42	271	124	233	264	268	2,498
V	25	49	22	83	46	47	68	140	127	541	179	67	1,293
R	1,741	65	2,005	901	238	18	6	16	1,869	769	5,931	5,088	18,648
X	1,368	275	43	1,904	2,805	4,632	14	3,166	1,266	4,194	6,975	7,799	34,440
D	681	501	223	149	245	462	186	910	3,606	5,802	6,800	2,124	21,689
12.24.12	-	-	-	-	-	-	-	0	-	0	150	574	724
STRAIGHT N													
Ammo. Nit.	3,113	873	35	77	1,096	827	167	61	25	2,874	1,896	869	11,912
Ammo. Sulf.	6	11	34	2	2	2	22	10	1	5	1	19	116
Urea	9,409	2,425	1,212	1,502	958	1,532	127	523	2,525	3,647	7,229	13,336	44,425
Sodium Nit. *1	10	1	3	1	1	5	3	2	21	5	2	24	77
CAN	-	-	-	-	-	-	5	-	-	-	-	1,902	1,907
STRAIGHT P													
SSP	4	14	9	1	1	0	6	10	11	23	31	22	131
TSP *1	63	21	2	9	67	72	44	22	53	84	34	49	520
Mixed SSP/TSP *1	4	7	2	2	3	-	-	-	-	5	0	-	23
STRAIGHT K													
SOP	2	4	26	0	105	0	1	1	14	6	6	3	167
MOP	5	17	5	5	1	3	9	14	14	2	9	-	83
OTHERS *1													
Gypsum	4	-	2	0	2	-	-	5	-	0	-	-	14
Sub Std. Fert.	493	204	60	14	62	76	396	86	1,157	448	997	1,092	5,087
Lime Mixture	-	-	-	-	-	9	29	9	-	69	43	281	441
Total *1	16,962	4,828	3,817	4,856	6,152	7,732	1,125	5,146	10,814	18,706	30,547	33,516	144,201

Source: NAMBOARD

Note: *1 The data does not coincide with that of Table AII-1-6.

Table AII-1-20 MONTHLY SHIPMENT OF FERTILIZER BY GRADE IN ZAMBIA, 1985

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
COMPOUND													
A	-	-	-	-	-	-	-	-	-	-	-	-	-
C	285	114	54	415	487	55	29	99	503	431	475	1,144	4,092
V	17	20	83	14	78	32	99	69	388	293	95	6	1,193
R	4,010	534	10	51	19	527	185	339	907	2,410	6,905	6,363	22,260
X	6,225	1,916	74	156	89	68	355	1,167	1,874	3,679	3,561	7,819	26,983
D	1,884	884	294	653	604	727	495	2,563	4,554	8,579	9,423	26,858	57,518
12.24.12	171	35	-	-	-	-	-	-	0	-	8	1	214
STRAIGHT N													
Ammo. Nit.	1,156	583	81	115	386	319	64	316	588	887	1,303	3,577	9,375
Ammo. Sulf.	26	3	2	2	6	9	868	53	0	1	1	1	972
Urea	18,672	7,692	81	203	301	384	714	1,527	4,003	6,876	9,066	26,816	76,335
Sodium Nit.	5	5	9	1	2	8	2	3	2	26	1	5	69
CAN	2,506	661	121	88	4	2	23	17	42	513	503	306	4,786
STRAIGHT P													
SSP	1	1	8	5	1	0	8	2	51	18	55	6	155
TSP	18	185	7	26	37	9	74	15	87	68	170	53	749
Mixed SSP/TSP	106	45	0	3	2	-	-	-	-	-	-	-	156
STRAIGHT K													
SOP	34	1	1	0	19	11	10	1	2	0	1	0	80
MOP	15	3	5	10	14	7	3	2	1	1	0	3	64
OTHERS													
Gypsum	3	1	-	0	-	0	0	0	0	-	0	0	5
Sub Std. Fert.	860	426	205	34	71	772	642	593	689	1,025	512	219	6,048
Lime Mixture	1	17	0	5	0	0	1	-	4	91	3	4	126
Total	35,997	13,126	1,038	1,781	2,117	2,931	3,571	6,766	13,696	24,897	32,082	73,180	211,180

Source: NAMBOARD

Table AII-1-21 MONTHLY SHIPMENT OF FERTILIZER BY TYPE IN ZAMBIA, 1983

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Basal Dressing	4,384	754	798	1,424	295	374	2,299	6,666	15,083	19,829	24,954	12,677	89,535
Top Dressing	10,363	7,278	1,320	728	617	384	1,661	446	4,822	12,486	20,676	8,111	68,892
Tobacco Compound	139	74	361	453	90	54	17	233	433	290	434	515	3,092
Phosphate Fert	26	2	15	9	12	2	6	7	8	88	560	84	818
Potash Fert	8	4	5	5	5	3	2	3	28	23	79	6	171
Mixed SSP/TSP	126	0	-	500	-	-	-	-	-	-	-	-	627
Sub Std Fert	238	188	13	34	15	44	54	36	159	497	457	525	2,262
Others	28	24	12	15	11	15	2	7	134	2	8	142	402
Total	15,312	8,325	2,523	3,168	1,045	876	4,041	7,398	20,666	33,216	47,168	22,059	165,798

Source: NAMBOARD

Notes:
- Basal Dressing: Compound-R, Compound-X and Compound-D
- Top Dressing: Ammonium Nit., Urea and CAN
- Tobacco Compound: Compound-A, Compound-C, Compound-V and Sodium Nit.
- Phosphate Fert: SSP and TSP
- Potash Fert: SOP and MOP
- Mixed SSP/TSP: Mixed SSP/TSP
- Sub Std Fert: Sub Std Fert
- Others: 12.24.12, Gypsum, Lime Mixture and Ammonium Sulf.

Table AII-1-22 MONTHLY SHIPMENT OF FERTILIZER BY TYPE IN ZAMBIA, 1984

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Basal Dressing	3,791	840	2,272	2,953	3,288	5,112	206	4,092	6,741	10,765	19,706	15,011	74,776
Top Dressing	12,522	3,298	1,246	1,579	2,054	2,359	299	584	2,550	6,521	9,125	16,107	58,244
Tobacco Compound	69	411	160	291	566	98	112	313	273	779	444	358	3,874
Phosphate Fert	66	35	11	10	68	73	50	32	64	107	65	71	651
Potash Fert	7	20	30	5	106	3	10	15	28	8	15	2	250
Mixed SSP/TSP	4	7	2	2	3	-	-	-	-	5	0	-	23
Sub Std Fert	9	11	36	3	4	11	52	25	1	75	194	874	1,295
Others	493	204	60	14	62	76	396	86	1,157	448	997	1,092	5,087
Total	16,962	4,828	3,817	4,856	6,152	7,732	1,125	5,146	10,814	18,706	30,547	33,516	144,201

Source: NAMBOARD

Note: See Table AII-1-21.

Table AII-1-23 MONTHLY SHIPMENT OF FERTILIZER BY TYPE IN ZAMBIA, 1985

(Unit: ton of product)

	January	February	March	April	May	June	July	August	September	October	November	December	Total
Basal Dressing	12,119	3,334	379	860	712	1,322	1,035	4,070	7,335	14,668	19,889	41,040	106,762
Top Dressing	22,335	8,936	284	406	690	706	800	1,859	4,636	8,275	10,873	30,698	90,496
Tobacco Compound	308	139	146	430	566	95	130	172	893	750	571	1,155	5,354
Phosphate Fert	19	186	15	31	37	9	82	17	139	85	225	59	904
Potash Fert	49	4	6	10	33	18	12	2	3	1	1	3	144
Mixed SSP/TSP	106	45	0	3	2	-	-	-	-	-	-	-	156
Sub Std Fert	860	426	205	34	71	772	642	593	689	1,025	512	219	6,048
Others	201	56	3	7	6	9	869	53	4	92	11	6	1,317
Total	35,997	13,126	1,038	1,781	2,117	2,931	3,571	6,767	13,696	24,897	32,082	73,180	211,180

Source: NAMBOARD

Notes: See Table AII-1-21.

Table AII-1-24 MONTHLY SHIPMENT PATTERN OF FERTILIZER BY TYPE IN ZAMBIA, 1983-1985

(Unit: % of yearly total and ave. and std. deviation)

		January	February	March	April	May	June	July	August	September	October	November	December	Total
Basal Dress.	1983	4.9	0.8	0.9	1.6	0.3	0.4	2.6	7.4	16.8	22.1	27.9	14.2	99.9
	1984	5.1	1.1	3.0	3.9	4.4	6.8	0.3	5.5	9.0	14.4	26.4	20.1	100.0
	1985	11.4	3.1	0.4	0.8	0.7	1.2	1.0	3.8	6.9	13.7	18.6	38.4	100.0
Average		7.1	1.7	1.4	2.1	1.8	2.8	1.3	5.6	10.9	16.7	24.3	24.2	-
Std. Deviation		3.7	1.2	1.4	1.6	2.3	3.5	1.2	1.8	5.2	4.7	5.0	12.6	-
Top Dress.	1983	15.0	10.6	1.9	1.1	0.9	0.6	2.4	0.6	7.0	18.1	30.0	11.8	100.0
	1984	21.5	5.7	2.1	2.7	3.5	4.0	0.5	1.0	4.4	11.2	15.7	27.7	100.0
	1985	24.7	9.9	0.3	0.4	0.8	0.8	0.9	2.1	5.1	9.1	12.0	33.9	100.0
Average		20.4	8.7	1.4	1.4	1.7	1.8	1.3	1.2	5.5	12.8	19.2	24.5	-
Std. Deviation		4.9	2.7	1.0	1.2	1.5	1.9	1.0	0.8	1.3	4.7	9.5	11.4	-
Tobacco Comp.	1983	4.5	2.4	11.7	14.6	2.9	1.7	0.6	7.5	14.0	9.4	14.1	16.6	100.0
	1984	1.8	10.6	4.1	7.5	14.6	2.5	2.9	8.1	7.0	20.1	11.5	9.2	99.9
	1985	5.7	2.6	2.7	8.0	10.6	1.8	2.4	3.2	16.7	14.0	10.7	21.6	100.0
Average		4.0	5.2	6.2	10.0	9.4	2.0	2.0	6.3	12.6	14.5	12.1	15.8	-
Std. Deviation		2.0	4.7	4.8	4.0	5.9	0.4	1.2	2.7	5.0	5.4	1.8	6.2	-
Phos. Fert.	1983	3.2	0.2	1.8	1.1	1.5	0.2	0.8	0.8	0.9	10.7	68.4	10.3	99.9
	1984	10.2	5.4	1.6	1.5	10.4	11.2	7.6	4.9	9.8	16.4	10.0	10.9	99.9
	1985	2.1	20.5	1.6	3.4	4.1	1.0	9.1	1.9	15.3	9.4	24.9	6.5	99.8
Average		5.2	8.7	1.7	2.0	5.3	4.1	5.8	2.5	8.7	12.2	34.4	9.2	-
Std. Deviation		4.4	10.5	0.0	1.2	4.6	6.1	4.4	2.1	7.3	3.7	30.3	2.4	-
Potash Fert.	1983	4.6	2.1	3.1	3.2	2.8	1.9	1.0	2.0	16.1	13.7	46.2	3.3	100.0
	1984	3.0	8.1	12.1	2.1	42.6	1.2	3.9	6.0	11.2	3.2	5.9	0.8	100.1
	1985	34.1	2.8	4.2	7.1	22.9	12.6	8.6	1.7	1.9	1.0	0.7	2.4	100.0
Average		13.9	4.3	6.5	4.1	22.8	5.2	4.5	3.2	9.7	6.0	17.6	2.2	-
Std. Deviation		17.5	3.3	4.9	2.6	19.9	6.4	3.8	2.4	7.2	6.8	24.9	1.3	-
Total	1983	9.2	5.0	1.5	1.9	0.6	0.5	2.4	4.5	12.5	20.0	28.4	13.3	99.8
	1984	11.8	3.3	2.6	3.4	4.3	5.4	0.8	3.6	7.5	13.0	21.2	23.2	100.1
	1985	17.0	6.2	0.5	0.8	1.0	1.4	1.7	3.2	6.5	11.8	15.2	34.7	100.0
Average		12.7	4.8	1.5	2.0	2.0	2.4	1.6	3.8	8.8	14.9	21.6	23.7	-
Std. Deviation		4.0	1.5	1.0	1.3	2.0	2.6	0.8	0.7	3.2	4.4	6.6	10.7	-

Source: Tables AII-1-21 through AII-1-23.

Table AII-1-25 PRICES OF FERTILIZER BY GRADE IN ZAMBIA, 1970-1986

(Unit: Kwacha/50kg bag)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
COMPOUND																	
A	3.52	2.18	3.00	4.00	4.80	7.00	7.00	7.00	7.00	9.00	7.00	9.15	13.15	23.30	24.95	24.95	75.00
C	3.74	2.48	3.20	3.90	3.90	6.75	6.75	6.75	8.75	11.00	9.00	11.15	14.65	23.80	26.45	26.45	80.00
V	3.72	2.48	3.16	3.90	3.90	6.00	6.00	6.00	6.00	10.00	8.00	10.15	14.15	23.30	25.95	25.95	78.00
R	3.64	2.70	3.55	4.25	4.25	6.80	6.80	6.80	8.80	11.79	9.75	11.94	14.95	24.10	26.75	26.75	80.00
X	4.14	2.75	3.50	4.15	4.15	6.70	6.70	6.70	8.70	11.79	9.79	11.94	14.95	24.10	26.75	26.75	80.00
D	4.15	2.75	3.50	4.00	4.00	6.55	6.55	6.55	8.55	11.60	9.60	11.75	14.95	24.10	26.75	26.75	80.00
STRAIGHT N																	
Ammo. Nit.	3.46	2.43	2.95	3.80	3.80	6.00	6.00	6.00	7.80	11.08	9.08	10.60	14.08	23.20	25.85	25.85	56.00
Ammo. Sulf.	2.67	1.83	2.20	3.00	3.00	4.80	4.80	4.80	6.20	9.25	7.25	9.40	13.40	22.55	25.20	25.20	48.00
Urea	4.19	2.80	3.55	4.05	4.05	6.75	6.75	6.75	8.75	11.65	9.65	10.95	14.95	24.10	26.75	26.75	65.00
Sodium Nit.	3.07	2.65	3.35	4.00	4.00	7.00	7.00	7.00	9.35	13.20	11.20	13.35	16.35	25.50	28.15	28.15	48.00
CAN	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	48.00
STRAIGHT P																	
SSP	2.26	1.48	1.90	1.90	1.90	4.50	4.50	4.50	5.85	9.20	7.20	9.35	13.35	22.50	25.15	25.15	50.00
TSP	4.70	3.13	4.00	3.90	3.90	6.45	6.45	6.45	8.35	13.50	11.50	13.65	16.65	25.80	28.45	28.45	64.00
Mixed SSP/TSP	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	50.00
STRAIGHT K																	
SOP	3.36	2.65	3.35	4.20	4.20	4.20	4.20	4.20	4.20	5.55	5.55	7.70	11.70	20.85	23.50	23.50	80.00
MOP	3.09	2.03	2.60	3.60	3.60	3.60	3.60	3.60	3.60	4.80	4.80	6.95	10.95	21.10	23.75	23.75	55.00
OTHERS																	
Lime Mixture	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	7.00	N.A.	6.00	8.15	15.20	21.30	23.95	N.A.	N.A.
Gypsum	N.A.	1.75	2.10	2.10	2.10	2.10	2.10	2.10	N.A.	N.A.	N.A.	N.A.	8.90	18.05	20.70	N.A.	48.00

Source: NAMBOARD

Notes: 1970-1978: Prices in 1970/71-1978/79
1979: From August 13, 1979 to May 31, 1980
1980: From June 1, 1980 to June 30, 1981
1981: From July 1, 1981 to July 29, 1982
1982: From July 30, 1982 to April 30, 1983
1983: From May 1, 1983 to May 2, 1984
1984: From May 3, 1984
1986: Sept. 17, 1986

Annex II-2

NATURAL CONDITION RELATING TO AGRICULTURAL PRODUCTION IN ZAMBIA

Zambia belongs to tropical area. The major natural condition affecting agricultural cultivation may be summrized in the following 3 points;

1. Around 80% of the land is distributed on highland area of 900 to 1,500 meters sea level (Figure AII-2-1). The remaining 12% is in the escarpment zone formulated by rivers represented by Zambezi, Luangua and Kafue Rivers, with 5% of rift valley floors of these rivers.

   Most of the area of the country may be categorized cultivable except for swamp area on lower part of high land, which accounts for around 15% of total area. However, actually, only limited area is used for cultivation because of other factors.

2. The land belongs to the savanna climate zone, in which dry season and rainy season are defined clearly. The dry season lasts May through October, while the rainy season lasts November through April. The dry season may be divided into two sub-seasons, namely lower temperature sub-season (May through August), and higher temperature sub-season. Since no rainfall can be expected and the difference in the temperature within a day or month is quite distinct in the dry season, only the pasture and perennial crops may be managed to grow, and short term crops cannot be grown without irrigation. In the case of rainy season, the rainfall and temperature are quite adequate for the plant growing with modest sunshine of 4 to 9 hours a day. Thus, the cultivation is limited to this season in Zambia (Tables AII-2-1 through 3 and Figure AII-2-2).

3. With respect to the soil condition, the most part of the land is on the sandy, and acidic soil. The fertility of the soil is generally low (Figures AII-2-3 and 4). The strong rainfall has leached the base of parent rock, and the clay has transferred to lower part of the soil. As a result, in the heavy rain area in the northern part

and northwestern part of the country, the soil lacks the calcium and magnesium, while being abundant in free aluminum.

The area with 800 to 1,000 mm of annual precipitation, except for Barotse sand, the leaching of base and transfer of clay down to lower part of the soil are not progressed as in the case of the former case. Therefore, the weak acidic soil with rich base can be found in Central and Lusaka provinces. However, even with this level of annual rainfall, the most of the soil in Central and Southern provinces are classified as the strong acidic soil with iron and magnesium leached out due to poor clay soil.

The soil with less than 800 mm of annual precipitation, distributed in the dry area, is abandunt in base, neutral, and clayey. However, this type of soil is limited to the flat area along Luangua river.

Among the above, availability of adequate rainfall is the most critical factor for cultivation. The agricultural zoning in Zambia may be summarized as follows (Figure AII-2-5):

1. Heavy rainy zone; the cultivation period is long (150 days), and therefore, advantageous in selection of kind and variety of crops. However, on the other hand, there is difficulty in controlling weed, pest and insect, and soil erosion. The soil is strongly acidic and requires intensive cultivation practice for crop growing. The zone is backward in agricultural production.

2. Medium rainy zone; Cultivable period lasts for 120-130 days a year. Basically, this is the most suitable zone for crop growing, although in germination period and maturation period the shortage of rainfall is observed especially in southern part of the zone. Sandy acidic soil is widely distributed except for Kafue river area, where weak acidic, base-rich, and fertile soil is observed. The zone is the most developed area of commercial agriculture with high development potentiality further.

3. Semi-dry zone; Barotse sandy soil is distributed over the region, and penetration of water into the soil is rapid. Thus, plant growing is quite hard even in the rainy season. The soil fertility

is very low, and the development of agriculture is almost impossible in this zone.

4. Valley climate zone; the cultivable period is limited to 90 days a year. The irrigation is indispensable for stable cultivation. At present, the crop is grown only in the season when the climatic condition is suitable for cultivation, but in the future with the development of irrigation facilities, this zone may be regarded as the high productivity area of agriculture. For the sloping area, anti soil erosion measure is essential, but the river plain area is quite adequate for cultivation with fertile soil.

Figures AII-2-6 through 7 show the distribution of farming in the country. Table AII-2-4 indicates the cultivation season by agricultural zoning.

Table AII-2-1 AVERAGE TEMPERATURE

(Unit: °C)

Province	Location	Elevation (m)	*)	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Ave.
Northwestern	Mwinilunga	1,363	I	16.1	18.6	22.3	21.8	20.8	20.4	20.5	20.5	20.6	20.3	18.1	15.8	19.7
			II	26.1	28.6	30.5	30.1	27.1	25.9	26.0	25.9	26.4	29.1	26.9	25.6	27.2
			III	6.4	8.9	12.3	14.4	15.7	16.2	16.1	16.1	15.9	14.4	10.0	6.5	12.7
	Zambezi	1,078	I	17.2	20.0	23.9	24.7	23.1	22.5	22.5	22.3	22.4	22.1	19.5	16.9	21.4
			II	26.8	29.6	33.0	32.0	29.8	28.3	28.3	28.0	28.6	29.3	28.4	26.4	29.1
			III	7.1	10.2	14.5	16.6	17.4	17.6	17.6	17.6	17.3	15.4	11.1	7.6	14.2
Luapula	Kawambwa	1,324	I	18.2	20.2	22.7	22.9	21.1	20.6	20.7	20.8	20.0	20.9	19.9	18.2	20.5
			II	26.0	28.0	30.3	29.9	27.2	26.0	26.2	26.3	26.5	27.0	26.9	25.8	27.2
			III	10.9	12.8	15.8	16.9	16.5	16.5	16.5	16.6	16.5	16.2	13.9	11.2	15.1
	Mansa	1,259	I	16.3	18.4	21.5	23.3	22.4	21.4	21.3	21.5	21.3	20.8	18.8	16.3	20.3
			II	25.2	27.3	30.2	31.5	28.7	26.8	26.8	26.8	26.9	27.1	26.7	25.2	27.4
			III	7.9	9.5	12.9	15.5	17.0	17.0	16.9	17.0	16.7	15.3	11.5	8.5	13.8
Northern	Mbala	1,673	I	16.9	18.5	20.3	21.0	19.7	18.6	18.5	18.6	19.0	19.1	18.3	16.9	18.8
			II	24.0	25.5	27.2	27.6	25.2	23.2	23.0	23.3	24.1	24.6	24.7	23.9	24.7
			III	10.3	11.6	13.7	15.1	14.5	14.7	14.6	14.7	14.8	14.6	12.7	10.6	13.5
	Kasama	1,384	I	16.9	18.8	21.7	23.3	22.2	20.8	20.5	20.5	20.7	19.8	19.0	17.1	20.1
			II	24.7	26.7	28.7	31.1	28.9	26.5	26.1	26.2	26.4	26.3	25.8	24.5	26.8
			III	9.3	10.5	13.7	15.7	17.4	16.1	16.1	16.1	16.1	15.3	12.5	9.3	14.0
Copperbelt	Ndola	1,270	I	16.0	18.5	21.8	23.7	22.5	21.2	21.0	21.1	21.1	20.3	19.9	15.9	20.3
			II	24.6	27.1	30.1	31.5	28.9	26.9	26.3	26.3	26.9	27.2	26.3	24.5	27.2
			III	7.1	9.6	12.7	15.9	17.0	17.1	17.0	16.9	16.2	14.1	10.2	7.4	13.4
Eastern	Chipata	1,032	I	18.1	20.3	23.6	25.9	25.0	22.9	22.2	22.2	22.2	21.8	20.0	18.0	21.9
			II	24.7	27.0	30.0	32.2	31.0	28.1	27.1	27.1	27.5	27.5	26.7	24.7	27.8
			III	11.3	13.8	17.3	19.9	19.5	18.4	17.9	17.9	17.6	16.5	13.8	11.7	16.3
Central	Kabwe	1,207	I	15.7	18.2	21.9	24.2	23.1	21.6	21.4	21.3	21.1	20.2	18.1	15.8	20.2
			II	23.2	25.8	29.4	31.5	29.2	26.8	26.6	26.5	26.8	26.7	25.4	23.2	26.8
			III	8.1	10.7	14.3	17.1	17.6	17.5	17.3	17.2	16.3	14.4	11.3	8.7	16.2
Lusaka	Lusaka	1,213	I	15.8	18.5	22.3	24.6	23.1	21.4	21.2	21.0	20.9	20.0	17.9	15.7	20.2
			II	23.2	25.9	29.2	31.1	29.2	26.7	26.6	26.5	26.7	26.4	25.2	23.1	26.7
			III	9.0	11.7	15.5	18.3	17.9	17.2	17.2	17.0	16.2	14.4	11.3	8.8	14.5
Southern	Choma	1,267	I	13.4	16.0	19.8	22.7	21.7	21.6	21.4	21.2	20.5	19.2	16.3	13.3	18.9
			II	22.6	25.4	29.0	31.2	28.9	26.9	26.7	26.4	26.6	26.5	25.0	22.5	26.5
			III	4.1	6.4	10.5	14.0	16.0	16.6	16.5	16.3	15.0	12.3	7.9	4.7	11.7
	Livingstone	986	I	15.9	18.9	23.5	26.3	25.1	23.8	23.5	23.3	23.1	22.0	18.9	15.8	21.7
			II	25.3	28.3	32.2	34.1	31.8	29.5	29.2	29.0	29.7	29.7	29.8	25.1	29.3
			III	6.4	9.1	14.3	18.3	18.9	18.1	18.7	18.5	17.3	14.9	10.1	6.6	14.3
Western	Mongu	1,053	I	16.8	20.4	24.3	25.5	23.9	23.1	23.1	22.8	23.0	22.3	19.8	17.3	12.9
			II	26.7	29.7	33.0	34.0	30.9	28.9	28.7	28.0	28.7	29.3	28.2	26.2	29.4
			III	9.1	11.7	15.9	17.6	17.9	18.3	18.5	18.6	18.3	16.4	12.2	8.6	15.3

Source: Meteorological Dept. Agrometeorological Report, No. 9, 1985.

Notes: *) I: Monthly Average II: Monthly Average of Daily Highest III: Monthly Average of Daily Lowest

Table AII-2-2 PRECIPITATION

(Unit: mm)

Province	Location	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	Total
Northwestern	Mwinilunga	0	3	18	84	219	263	231	225	274	96	12	0	1,425
	Zambezi	0	0	6	41	152	212	219	208	170	38	4	0	1,050
Luapula	Kawambwa	0	1	15	85	199	263	221	197	267	139	19	0	1,406
	Mansa	0	0	4	28	151	232	230	208	211	66	4	0	1,134
Northern	Mbala	0	1	6	17	135	259	237	210	227	123	15	1	1,231
	Kasama	0	0	3	20	159	268	282	232	242	88	10	0	1,304
Copperbelt	Ndola	0	0	3	22	134	305	276	269	169	45	3	0	1,226
Eastern	Chipata	0	0	0	10	88	219	260	241	159	54	3	0	1,034
Central	Kabwe	0	2	2	21	96	265	238	199	115	24	4	0	966
Lusaka	Lusaka	0	0	2	18	95	219	203	177	84	25	12	1	836
Southern	Choma	0	0	4	25	104	202	204	174	91	25	9	1	839
	Livingstone	0	0	2	22	81	197	194	159	84	22	2	0	763
Western	Mongu	0	0	2	29	107	200	208	211	153	48	5	0	963

Source: Meteorological Dept.l Report, No. 9, 1985.

Table AII-2-3 AVERAGE SUNSHINE

(Unit: hour/day)

Province	Location	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Feb.	Mar.	Apr.	May	June
Northwestern	Mwinilunga	10.1	9.6	8.7	7.2	4.9	4.2	4.3	4.1	4.9	7.3	9.6	9.9	7.1
	Zambezi	9.8	9.7	9.2	8.1	6.1	5.6	5.4	5.4	6.0	8.1	9.5	9.6	7.7
Luapula	Kawambwa	9.9	9.7	8.5	7.5	5.4	4.0	4.1	4.6	4.8	7.1	9.3	9.9	7.0
	Mansa	10.4	10.5	9.8	8.7	7.3	4.7	4.7	4.8	5.1	6.8	9.8	10.0	7.7
Northern	Mbala	9.6	9.7	8.8	8.3	6.0	4.4	4.3	4.5	4.9	7.0	9.5	9.6	7.2
	Kasama	9.9	9.5	9.3	8.7	6.9	4.8	4.3	4.5	5.6	7.3	9.4	9.8	7.0
Copperbelt	Ndola	9.4	9.6	9.4	8.8	6.7	4.8	4.6	4.6	6.1	8.0	9.0	9.0	7.5
Eastern	Chipata	8.4	8.8	8.7	8.9	7.2	5.3	4.9	5.0	6.1	7.7	8.8	8.3	7.3
Central	Kabwe	9.5	10.1	9.9	9.5	6.9	5.5	5.7	5.7	7.1	8.5	9.6	9.2	8.1
Lusaka	Lusaka	9.3	9.4	9.4	8.8	6.9	5.2	5.6	5.7	6.9	8.2	9.0	8.7	7.8
Southern	Choma	9.4	9.9	9.9	9.3	6.7	5.4	6.0	5.8	7.2	8.5	9.2	9.1	8.0
	Livingstone	9.8	10.1	9.8	8.9	7.2	5.9	6.4	6.5	7.9	9.0	9.7	9.5	8.4
Western	Mongu	9.9	10.0	9.4	8.5	6.5	5.6	5.9	5.5	6.9	8.6	9.8	9.7	8.0

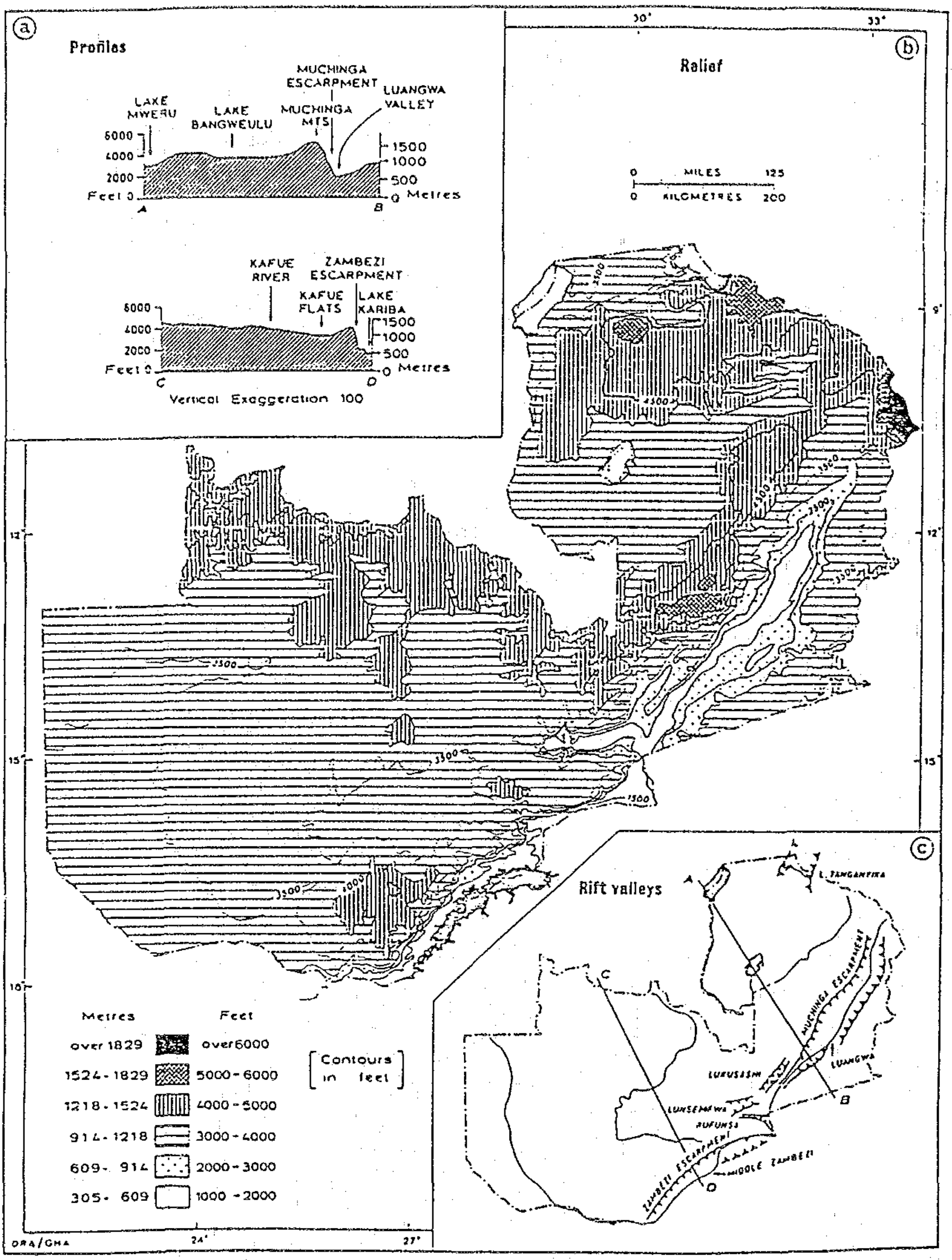
Source: Meteorological Dept., Agrometeorological Report, No. 9, 1985.

Table AII-2-4 CULTIVATION SEASON

Agricul-tural Zone	Province	Location	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Period of the Season (days)
	Northwestern	Mwinilunga								170
		Zambezi								160
I	Luapula	Kawambwa								190
		Mansa								165
	Northern	Mbala								160
		Kasama								160
	Copperbelt	Ndola								150
	Eastern	Chipata								135
II	Central	Kabwe								115
	Lusaka	Lusaka								125
	Southern	Choma								105
III	Western	Mongu								125
IV	Southern	Livingstone								90

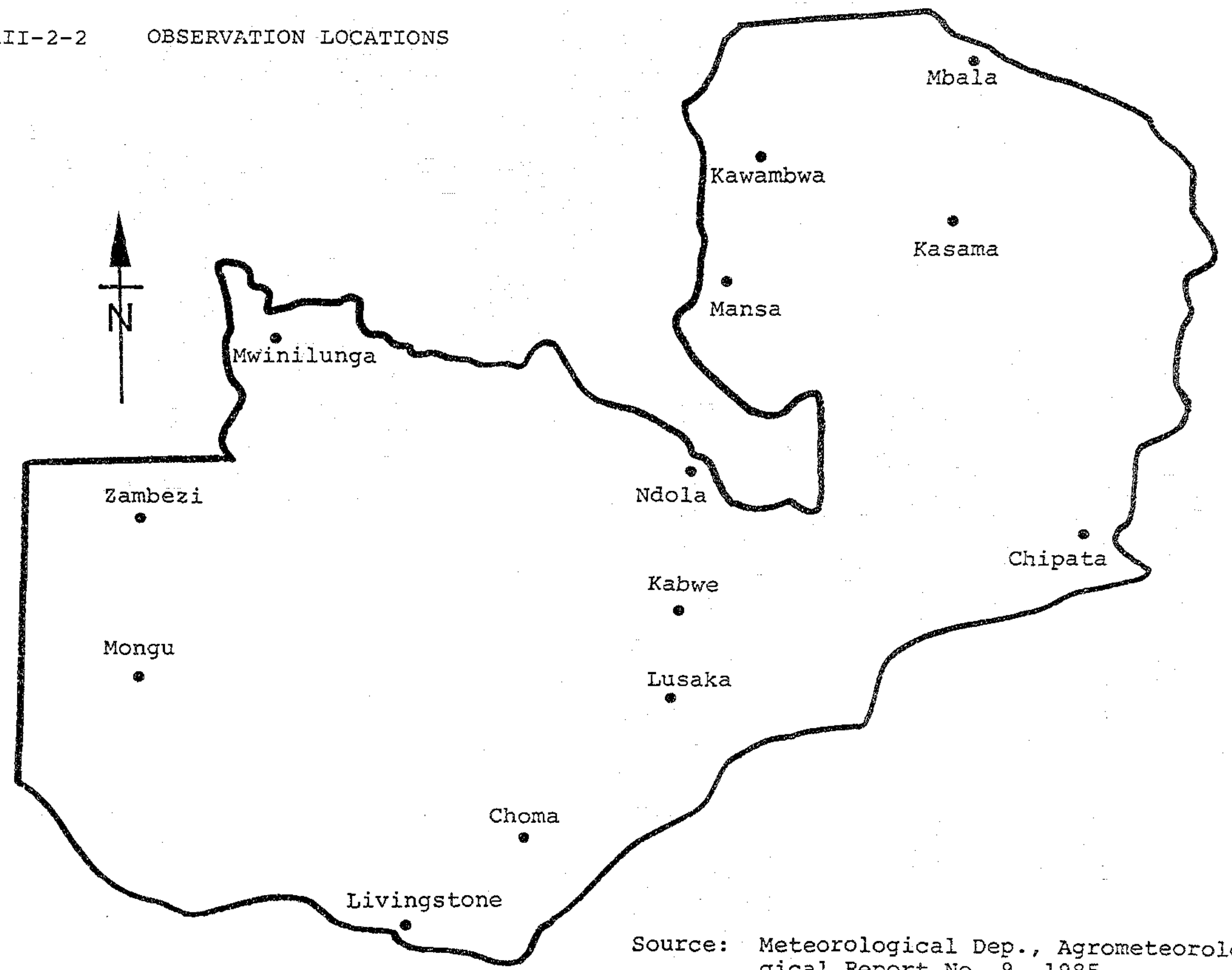
Source: Meteorological Dept. Agrometeorological Report, No. 9, 1985.

Figure AII-2-1 ELEVATION MAP OF ZAMBIA



Source: Zambia in Maps, University of London Press, 1971.

Figure AII-2-2 OBSERVATION LOCATIONS



Source: Meteorological Dep., Agrometeorological Report No. 9, 1985

Figure AII-2-3 SOIL MAP

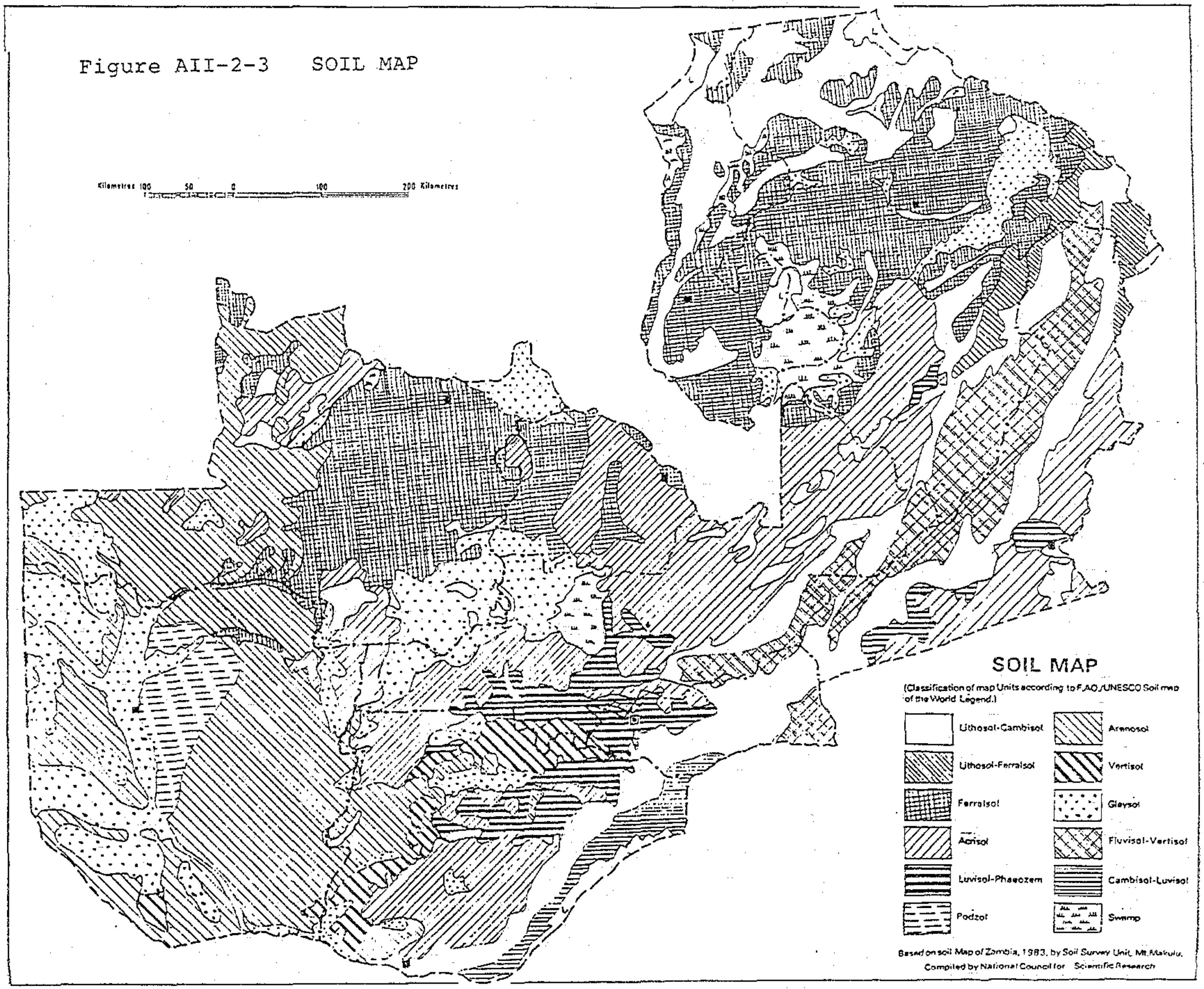
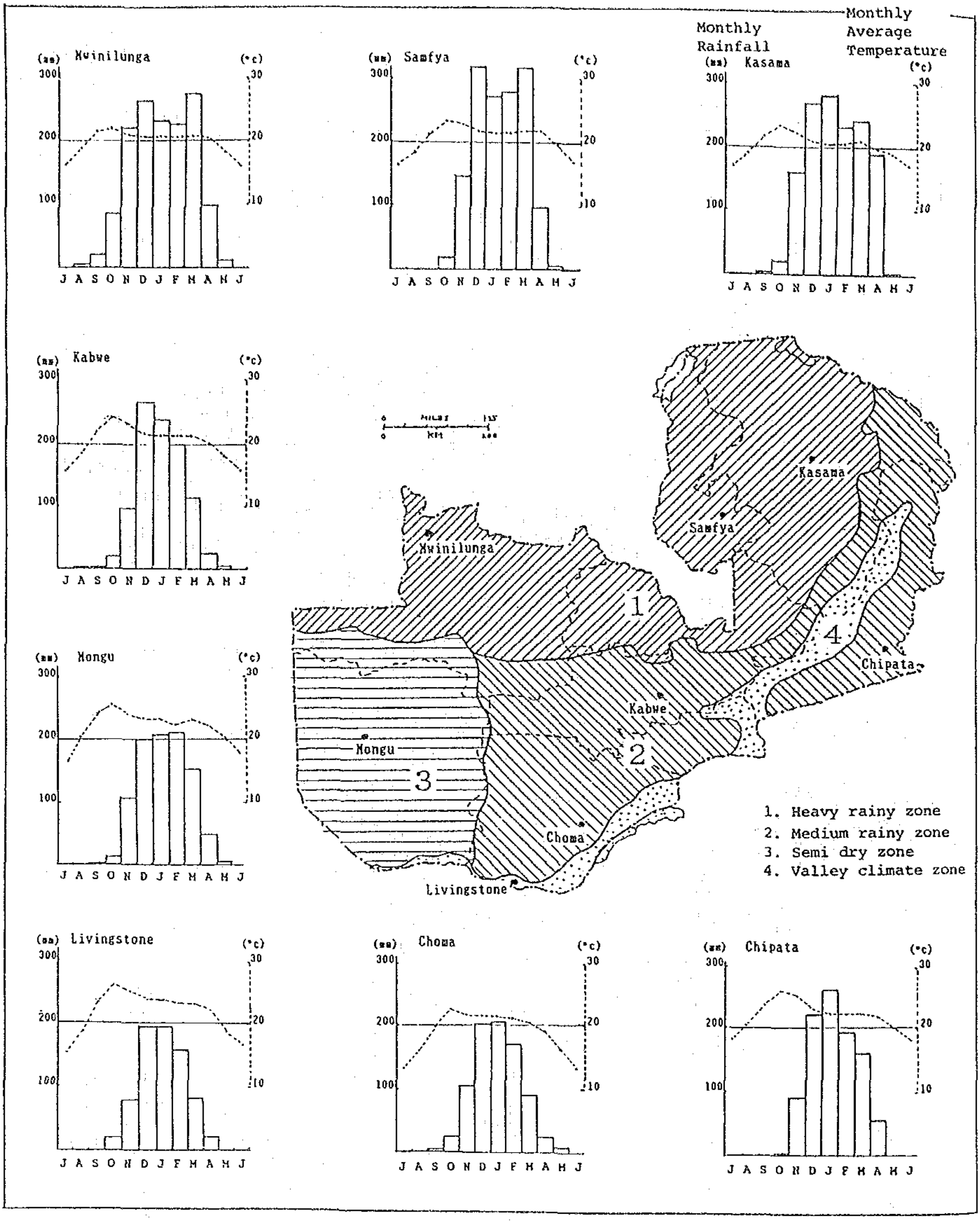


Figure AII-2-4 CLASSIFICATION OF AREA IN VIEW OF USE OF FMP AND LIME

Not suitable for Cultivation
- Urban areas and mines
- Forest estate/game parks
- Unsuitable soil/land condition for cultivation

Agricultural Area
- Acidic soil
- Non-acidic soil

Figure AII-2-5 AGRICULTURAL ZONING



Source: Meteorological Dept., Agrometeorological Report No. 9, 1985.

Figure AII-2-6 FARMING AREAS

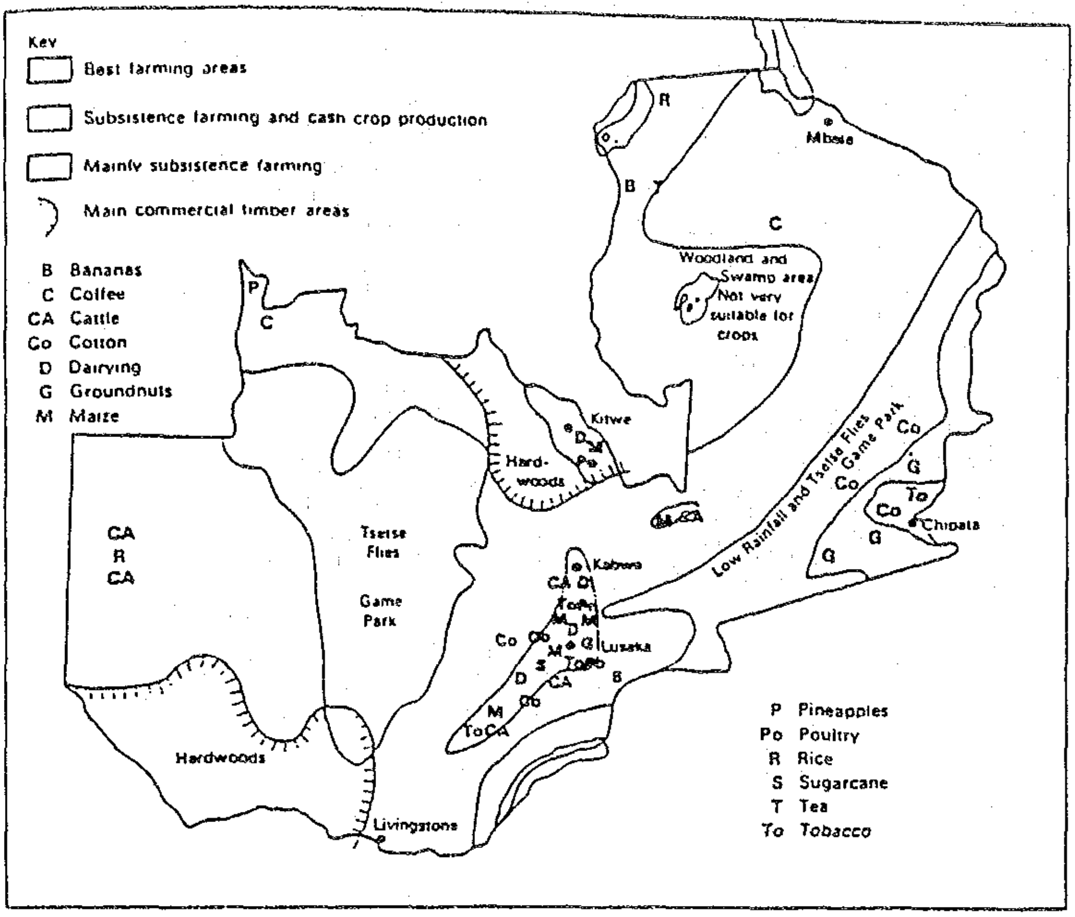
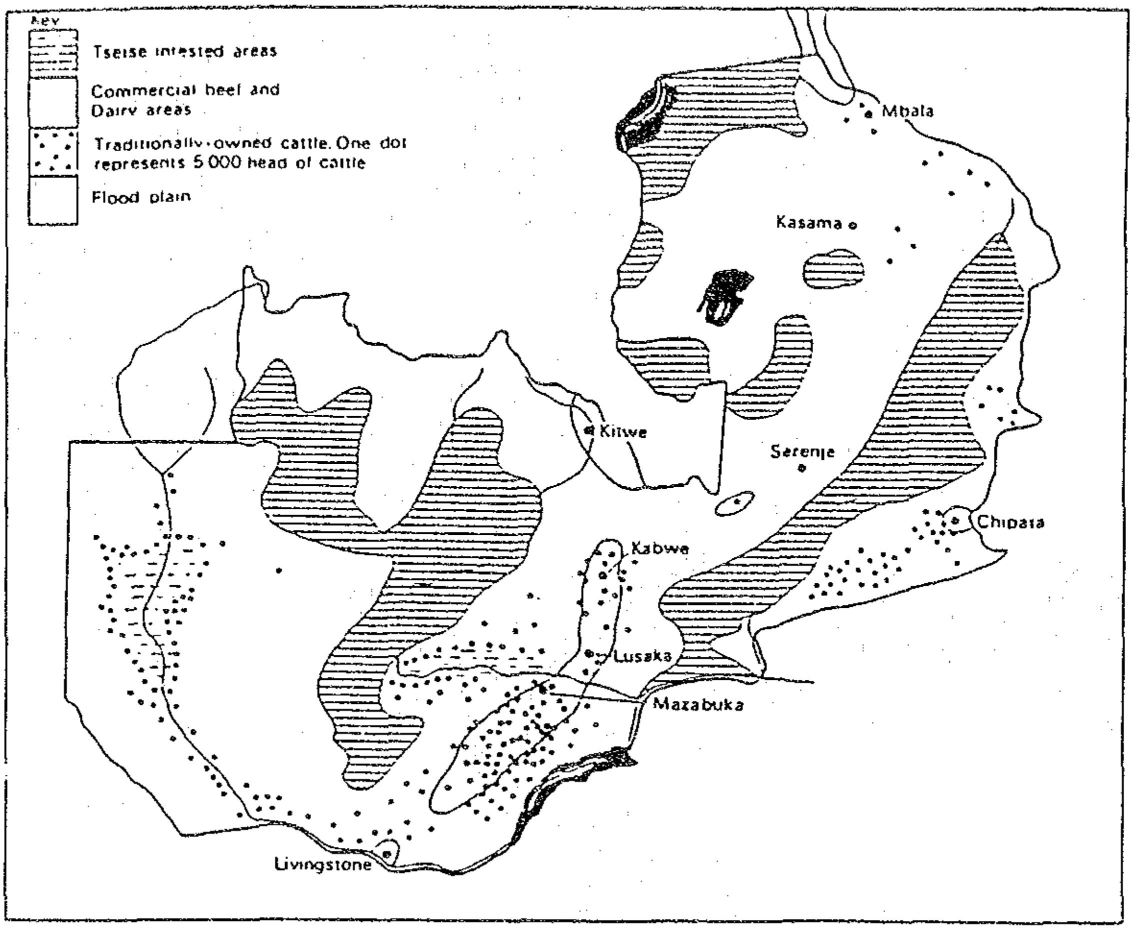


Figure AII-2-7 CATTLE FARMING AREA



Annex II-3

SUMMARY OF EXPERIMENTAL RESULTS ON PHOSPHATE APPLICATION IN ZAMBIA

(1) Preface

This annex summarizes the data on the effectiveness of the application of phosphate nutrient in Zambia obtained from the various experiments conducted in Zambia. The main point to be focused in this annex should be as follows;

1) Effectiveness of water-soluble phosphate on crop yield

2) Effectiveness of citric-soluble phosphate comparing with that of water-soluble phosphate

3) Effectiveness of FMP as a material to amend soil acidity

4) Required modification of standards and regulations for phosphate fertilizers in Zambia to introduce FMP

(2) Use of phosphate fertilizer in Zambia

In the case of soil with strong acidity, which is widely distributed in Zambia, the fixation of phosphate by soil is very high. Especially in the high rainfall area, saturation of aluminum is high and therefore, phosphate absorption coefficient is high resulting in poor effectiveness of phosphate application.

The recommended dosage of phosphate fertilizer in Zambia presently used for all the crops commonly, are as follows;

Low phosphate soil [1) .... 70-90 kg/ha
Medium phosphate soil [2) .... 40-60 kg/ha
High phosphate soil [3) ...... 20-30 kg/ha

(Note: 1) The land without application history of phosphate fertilizer such as newly cleared land or long-term-unused land. Bray I, P below 7 mg.

2) The land with continuous moderate phosphate application. Bray I, P 7-15 mg.

3) The land with continuous intensive phosphate application. Bray I, P above 15 mg.)

The recommendation as well as actual application practice is to use combination of compound fertilizer for basal dressing and straight nitrogen fertilizer for topdressing. The recommendation pattern is very simple over the country and various crops, and farmers can follow it easily.

All the phosphate is indicated to be applied in water soluble phosphate, although the nutrient content of phosphate fertilizer is regulated to express in total phosphate.

One of the characteristics of fertilizer recommendation in Zambia is the application of sulphur over the country. The sulphur is recommended to apply at more than 20 kg/ha, and all the compound fertilizer is regulated to contain more than 10-12 % of sulphur for this purpose. The sulphur should be in the form of sulphate. The sulphur contained in locally produced compound fertilizer derives from ammonium sulphate and sulphate of potash.

With the continuous application of sulphur in addition to the acidic nature of the soil, the application of lime has become imminent. The recommended dosage of lime is as follows;

	Maize/ sunflower		Cotton/ groundnuts/ soyabeans	
	pH*	Dosage (kg/ha)	pH*	Dosage (kg/ha)
Sandy soil	4.4	500-1,000	4.6	500-1,000
Sandy loam soil	4.6	1,000-1,500	4.8	1,000-1,500
Sandy clay soil	4.8	1,500-2,000	5.0	1,500-2,000

Note: * The minimum pH level allowable for the plant growth.

However, the lime has been seldom applied except for the large scale commercial farmers, because of economic reason.

(3) Effectiveness of application of water-soluble phosphate on crop yield in Zambia

The agronomic experiments to test the effectiveness of phosphate on crop yield have been carried out by Central Research Station at Mount Makulu, and Regional Reseach Stations using fertilizer containing water-soluble phosphate.

The results of these experiments may be summarized as follows;

1. In the case of strong acidic soil in the heavy rainfall area and the medium rainfall area, application of phosphate is indispensable for plant growth. The application of acidity amendment material such as lime is essential to get the effective phosphate response. The expected level of response to the phosphate is not necessarily the same even with the same acidity level.

2. In the weak acidic soil area, the significant phophate response can be expected with the balanced supply of plant nutrients. In this case, the objective of lime application is supply of base instead of amendment of soil acidity.

3. In the case of neutral and alkali soils, most of the applied phophate becomes insoluble fixed by the soil with the elapse of time. The phosphate should be water-soluble type. The small amount of application results in the significant response, while the excessive phosphate can not be utilized by the plant. For such soil, sulphur deficiency is often observed, and therefore, application of ammonium sulphate and SSP is effective. With application of these fertilizers, the pH of the soil is reduced and as a result, the insoluble phosphate becomes available again.

Tables AII-3-1 through 5 show the result of field experiments.

Table AII-3-1: Strong acidic soil Ferralsol with heavy rainfall. 20-60% of increase in the yield can be expected by application of 20 P2O5 kg/ha.

Table AII-3-2: Strong acidic soil Ferralsol in heavy rainfall area. Very significant response can be expected by application of 60 P205 kg/ha, and in addition to that, the application of phosphate is expected to stabilize the response of nitrogen.

Table AII-3-3: Strong acidic soil Ferralsol in heavy rainfall area. The response to nitrogen is more signifcant than that of other nutrients. The response to phosphate can be expected if phosphate is applied alone.

Table AII-3-4: Weak acidic soil Luvisol-Phaeozem in heavy rainfall area (Eastern province) and medium rainfall area (Magoye, Southern province). The response to phosphate is significant in both areas.

Table AII-3-5: In strong acidic soil, the response to phosphate is insignificant without lime application, while use of lime improve the phosphate response significantly. In the case of weak acidic soil (at Chisamba), the application of TSP is effective even without lime application, but the application of lime doubled the response.

(4) Effectiveness of citric soluble phosphate, and acidity ammendment effect of FMP

1) Effectiveness of citric soluble phosphate, and acidity ammendment effect of FMP

One of the characteristics of water-soluble phosphate is the quick acting nature. However, on the strong acidic soil where the base has been leached out, the phosphate is easily fixed to the soil and become insoluble absorbed by the exchangeable aluminum. Further, if it is applied excessively, the phosphate might be leached out without used.

By contrast, the citric soluble phosphate contained in the fused magnesium phosphate has two major advantages, namely;

1. Since citric soluble phosphate is insoluble to water, and low in absorption to the soil, the response is expected to be high.

2. The fused magnesium phosphate fertilizer contains calcium and magnesium. Therefore, it has the ability to ammend the soil acidity.

So far no definite experiments have been carried out to clarify the response to fused magnesium phosphate fertilizer in Zambia. However, according to the experiments conducted in Brazil on Oxisol of Cerrado (the soil of similar nature to the Zambian ferralsol soil), the response to citric soluble phosphate is equivalent to that of water-soluble phosphate. In addition to that, the application of fused magnesium phosphate amends the soil acidity. The brief summary of the expermental results are as follows;

Table AII-3-6: This table shows the profile of tested soil. The soil is dark red latosol of Cerrado in Brazil. The clay included is kaolin, which is the same as that of ferralsol in Zambia. The degree of aluminum saturation is extremely higher than that of ferralsol in Zambia; CEC and exchangable cations are almost same level, while its pH is lower. The crop tested is perennial fodder grass (Brachieria decumbens); the grass was harvested 12 times after seeded in February,1974 until June, 1978.

Table AII-3-7: The available phosphate from each tested phosphate fertilizer was compared. The available P2O5 from citric soluble phosphate was lower than that of water-soluble phosphate. The citric soluble phosphate is less quick active compared with that of water soluble phosphate. The amendment effect of soil pH is significant for fused magnesium phosphate, but 200 P2O5 kg/ha of application level seems optimum for this purpose.

Figure AII-3-1: The application effect of fused magnesium phosphate is significant with respect to reduction of exchangeable cation, increase in calcium and magnesium, and decline of degree of aluminum saturation. However, such effect can be expected only when it is applied heavily, namely more than 200 P2O5 kg/ha. The application of SSP decreases the degree of aluminum saturation even at 86 P2O5 kg/ha. This may be resulted from the existence of gypsum in SSP. In the case of Araxa phosphate rock, which is the raw material of the tested fused magnesium phosphate, the effect of application is insignificant. The difference in the effectiveness may be attributable to the heat treatment.

Table AII-3-8: The harvested amount of forage dry matter has not shown significant difference between SSP and FMP. This trend was observed in every harvesting time from the start. In the case of Araxa phosphate rock which is the raw material of tested FMP, the effect became significant only after second half of the second year. With respect to the decline of degree of aluminum saturation, the FMP is significantly effective compared with SSP. The relationship between the harvest of forage and application level of lime is not certain for all the tested fertilizers, and this may be attributable to the fact that the perennial crop is resistant against acidity.

In conclusion, firstly, the response of citric soluble phosphate is found comparable to that of water soluble phosphate on the strong acidic soil in tropical region, which is similar in nature to that of Zambia. Secondly, heavy application of FMP improve the soil condition, which can not be expected by the application of water-soluble phosphate.

However, unfortunately, no similar data were available on maize.

2) Examination of appropriate application method and granule size of FMP

In the case of water-soluble phosphate, the applied phosphate becomes unavailable in the strong acidic soil, and therefore, the band application is recommended to increase the density of phosphate content in the soil around the plant roots. However, this application method has two shortcomings; firstly, the residual effect of the application is hard to be expected, and secondly, the roots do not expand well and as a result, the plant becomes weak in resisting the drought.

In the case of application of citric soluble phosphate, there was not much difference in the yield among the different application method (Figure AII-3-2). However, for short term crops since the closer the distance from the root to the application point, the more significant the response in the case of water-soluble phosphate. It is recommended to use water-soluble phosphate by band application, in addition to the application of citric-soluble phosphate.

The citric soluble phoaphate is dissolved into weak acid. The time required for the dissolution depends largely on the granule size of the fertilizer. The smaller the granule size, the shorter the time required for dissolution and therefore, the residual effect will be hard to be expected. In the case of FMP, the smaller size of 70 mesh pass did not increase the effectiveness according to the phosphate absorption test for seedling of rice using silica sand as culture medium. The pot experiment of rice showed that with the application of FMP with grain size of 10 mesh on, the initial growth was poor but after active-tillering stage, the growth of the plant was the best among others, and phosphate absorption resulted in the best rate.

3) The required modification of regulations and specifications of FMP to introduce FMP into the market

a) The required modification of regulations on FMP

The method of analysis and required specifications of fertilizer is regulated by "Chapter 351 of the laws of Zambia, Agriculture (Fertilizers and Feed) Act". However, this law contains the regulation on water-soluble phosphate only. In case the other types of phosphate fertilizer such as citric soluble phosphate, is marketed, the additional regulation is required.

The major items recommended to be added in view of FMP marketing are as follows;

1. Methods of analysis of fertilizers (Section 52 (i) and Regulation 17); Add "Extraction of sample using 2% citric acid"

2. Limits of variation (Section 52 (g) and Regulation 18); Add "Citric soluble phosphorous"

3. Statement of analysis required for different classes of fertilizers; Add "Fused magnesium phosphate" and "percentage of citric soluble phosphorous"

4. Statement of particulars to be lodged with... (Section 30 and Regulation 13); Add "Percentage by weight of citric soluble phosphorous"

5. New regulation; Since there is significant difference in response depending on the granule size, it is recommended to add new regulation with respect to the granule size distribution.

b) The required modification of specifications used in the tender document of NAMBOARD

In addition to the above act, NAMBOARD is controlling the specifications and packaging of handling fertilizers. In this specifications, the items relating to citric soluble phosphate should be also included to distribute FMP. Major items to be revised or added are as follows;

1. Add FMP as "phosphate fertilizer", and "required contents.

2. Apply new specifications on granule size for FMP.

3. It is recommended to put the statement not only of nutrient contents but also of characteristics of response and recommended dosage on the bag, since the bag is one of the most suitable media for indication to the users. The characteristics to be described on the bag should be; 1) Citric soluble phosphate is contained and therefore, response is moderate over the plant growing period; 2) Alkali fertilizer, and therefore, application of appropriate volume will amend the acidity of the soil.

Table AII-3-1 MEAN MAIZE YIELD IN 100 KG/HA SHELLED GRAIN AT MISAMFU REGIONAL RESEARCH STATION (MN1074)

Year	P0	P1	S.E.±	K0	K1	pH (CaCl2)
1965-66	50.4	52.0	0.86	50.5	51.9	5.0
1966-67	49.7	53.8	1.29	49.4	54.1	
1967-68	34.6	34.4	1.16	34.2	34.8	
1968-69	37.1	42.6	1.61	37.3	42.5	
1969-70	24.9	33.8	1.56	26.1	32.6	4.3
1970-71	14.1	21.7	1.35	15.1	21.7	
1971-72	17.7	22.5	1.08	16.5	23.7	
1972-73	18.8	31.3	1.67	16.5	33.6	4.4
1973-74	22.6	31.8	1.60	20.5	34.0	
1974-75	10.7	16.3	1.52	9.2	17.7	4.3

Source: McPhillips, The Development of Fertilizer Recommendations for Maize with Particular Reference to the High Rainfall Areas of Northern Zambia, 1983.

Note: Concurrent with the introduction of 'X' mixture a trial series was initiated to evaluate the P and K responses over
3
the longer term. The trial was a 3 x 2 factorial with three levels of nitrogen and two levels of P and K

i.e. N0: 75	N1: 120	N2	: 175 kg per ha
P0: 0	P1: 20	(P_2O_5)	: 175 kg per ha
K0: 0	K1: 10	(K_2O)	: 175 kg per ha

Table AII-3-2 (1) EFFECT OF PHOSPHATE APPLICATION ON STRONG ACIDIC SOIL IN HEAVY RAIN AREA - DRY BEANS -

Level of Nitrogen (kg/ha)	Yield (kg/ha) at phosphate application: 0 (%)	30 (%)	60 (%)	Average (%)
0	103 (100)	135 (131)	247 (238)	162 (157)
67	183 (100)	470 (251)	507 (271)	388 (212)
134	68 (100)	356 (356)	447 (657)	290 (426)
Average	119 (100)	320 (268)	400 (336)	

Notes: 1. The figures in the parentheses show % increase of the yield to that of control.

2. North western RRS (Regional Research Station), Mwinilunga.

Source: Annual Report of Research Branch 1973-1974.

Table AII-3-2 (2) EFFECT OF PHOSPHATE APPLICATION ON STRONG ACIDIC SOIL IN HEAVY RAIN AREA - SOYBEAN, DRIED -

	P0 (%)	P1 (%)	P2 (%)	L0	L1	Average
N0	596 (100)	1,104 (185)	1,543 (285)	872	1,289	1,081
N1	573 (100)	1,758 (327)	1,035 (192)	859	1,361	1,110
N2	449 (100)	1,309 (291)	1,758 (391)	996	1,348	1,172
L0	527 (100)	996 (188)	1,204 (228)			
L1	527 (100)	1,784 (291)	1,686 (391)			
Average	527 (100)	1,390 (263)	1,445 (274)			

Notes: 1. The figures in the parentheses show % increase of the yield to that of control.

2. Level of application/ha

Nitrogen	N0 ..... 0kg	N1 ..... 60kg	N2 ..... 120kg
Phosphate	P0 ..... 0kg	P1 ..... 30kg	P2 ..... 60kg
Lime	L0 ..... 0kg	L1 ..... 2,000kg	

3. Copper belt RRS, Mufulira.

Source: Annual Report of Research Branch 1973-74.

Table AII-3-2 (3) EFFECT OF PHOSPHATE APPLICATION ON STRONG ACIDIC SOIL IN HEAVY RAIN AREA - SOYBEAN, DRIED -

	P0 (%)	P1 (%)	P2 (%)	L0	L1	Average
N0	650 (100)	1,090 (167)	870 (133)	955	785	870
N1	1,215 (100)	1,280 (105)	1,240 (102)	1,325	1,240	1,280
N2	1,600 (100)	1,310 (82)	1,660 (104)	1,480	1,570	1,525
L0	1,195 (100)	1,230 (102)	1,330 (111)			
L1	1,110 (100)	1,230 (102)	1,250 (112)			
Average	1,150 (100)	1,230 (106)	1,290 (112)			

Notes: 1. The figures in the parentheses show % increase of the yield to that of control.

2. Level of application/ha

Nitrogen	N0 ..... 0kg	N1 ..... 60kg	N2 ..... 120kg
Phosphate	P0 ..... 0kg	P1 ..... 30kg	P2 ..... 60kg
Lime	L0 ..... 0kg	L1 ..... 2,000kg	

3. Luapula RRS, Mansa.

Source: Annual Report of Research Branch 1973-74.

Table AII-3-3 (1) EFFECT OF PHOSPHATE APPLICATION ON STRONG ACIDIC SOIL IN MEDIUM RAIN AREA
- LONG TERM EXPERIMENT, SOYBEAN -

(Unit: kg/ha)

(Kg/ha)	1969-70	1970-71	1971-72	1972-73	1973-74
79N	6.6	5.2	6.3	4.9	3.5
135N	6.7	5.6	6.5	4.9	3.9
191N	7.2	6.5	7.0	4.9	4.6
0P	6.5	5.3	5.9	4.8	3.5
20P	7.2	6.2	7.3	5.2	4.5
0K	6.7	6.0	6.4	4.9	3.8
9K	7.0	5.9	6.8	5.0	4.2
0S	6.7	5.7	6.5	4.9	3.9
9S	6.7	5.8	6.7	5.0	4.1
Mean	6.8	5.8	6.6	4.9	4.0

Note: Kabwe, Central Province.

Source: Annual Report of Research Branch 1973-74.

Table AII-3-3 (2) EFFECT OF PHOSPHATE APPLICATION ON STRONG ACIDIC SOIL IN MEDIUM RAIN AREA

- BEANS, DRIED -

(Unit: kg/ha)

(Kg/ha)	P_2O_5	K_2O	Lime	Sulphur
0	652 (100)	757 (100)	571 (100)	623 (100)
30	890 (136)	781 (103)	967 (169)	914 (146)

Note: Mochipapa, Southern Province.

Source: Annual Report of Research Branch 1973-74.

Table AII-3-4 (1) EFFECT OF PHOSPHATE APPLICATION ON WEAK ACIDIC SOIL - BEANS, DRIED -

(Unit: kg/ha)

Level of Nitrogen (kg/ha)	Yield (kg/ha) at phosphate application: 0 (%)	15 (%)	30 (%)	Average (%)
0	514 (100)	481 (81)	466 (90)	466 (90)
67	607 (100)	1,041 (171)	952 (156)	967 (188)
134	856 (100)	1,110 (129)	1,034 (120)	1,000 (194)
Average	659 (100)	856 (129)	817 (123)	

Notes: 1. The figures in the parentheses show % increase of the yield to that of control.

2. Eastern RRS, Msekera.

Source: Annual Report of Research Branch 1973-1974.

Table AII-3-4 (2) EFFECT OF PHOSPHATE APPLICATION ON WEAK ACIDIC SOIL
- SOYBEAN, DRIED -

(Unit: kg/ha)

	P0 (%)	P1 (%)	P2 (%)	L0	L1	Average
N0	1,268 (100)	1,494 (118)	1,538 (121)	1,355	1,511	1,433
N1	1,871 (100)	1,904 (101)	1,613 (86)	1,737	1,856	1,796
N2	1,597 (100)	1,773 (111)	1,978 (123)	1,864	1,702	1,783
L0	1,546 (100)	1,739 (112)	1,671 (108)			
L1	1,612 (100)	1,708 (105)	1,749 (108)			
Average	1,579 (100)	1,724 (109)	1,710 (108)			

Notes: 1. The figures in the parentheses show % increase of the yield to that of control.

2. Level of application/ha

Nitrogen	N0 ..... 0kg	N1 ..... 60kg	N2 ..... 120kg
Phosphate	P0 ..... 0kg	P1 ..... 30kg	P2 ..... 60kg
Lime	L0 ..... 0kg	L1 ..... 2,000kg	

3. Southern RRS, Magoye.

Source: Annual Report of Research Branch 1973-74.

Table AII-3-5 EFFECT OF LIME ON PHOSPHORUS UPTAKE

Soil Type	Treatment	% Pdff	Total Uptake of Fertilizer P (mg)	Total Uptake of Soil P (mg)	% Utilization of Fertilizer P
Mufulira	TSP	34.28	0.47	0.88	0.74
Soil Series	TSP+CaCO3	62.16	7.02	4.34	5.95
Chisamba	TSP	43.48	6.00	7.80	5.05
Soil Series	TSP+CaCO3	74.03	11.53	4.05	9.71

Soruce: Munyinda, K.: Use of Lime in Management of Acid Soils, Seminar on Soil Productivity in High Rainfall Areas, 1983.

Note: %Pdff: the % Phosphorus derived from fertilizer.

Table AII-3-6 PROFILE ANALYSIS OF SELECTED OXISOLS AND ULTISOLS FROM EXPERIMENT STATIONS

Horizon (cm)	Clay %	Sand %	pH (1:1H2O)	Org.C %	Exchange Cations (meg/100g) AL	Ca Mg	K	CEC	Al Satn. %
0- 10	45	36	4.9	1.8	1.9	0.4	0.10	2.4	79
10- 35	48	33	4.8	1.2	2.0	0.2	0.05	2.2	89
35- 70	47	35	4.9	0.9	1.6	0.2	0.03	1.8	88
70-150	47	35	5.0	0.7	1.5	0.2	0.01	1.7	88
150-260	42	39	4.6	0.3	0.7	0.2	0.02	0.9	76

Source: EPFS, 1964

Note: Oxisol, Brasilia, Cerrado of Brazil. Typic Haplustox, fine, kaolinitic isohyperthermic. Dark Red Latosol Rrofile 1, Centro de Pesquisa Agropecuaria dos Cerrados.

Table AII-3-7 EFFECT OF DIFFERENT PHOSPHORUS SOURCES ON SOIL pH AND AVAILABLE P AFTER 24 DAYS INCUBATION ON A DARK RED LATOSOL

Source	Rate (Kg P205/ha)	Avail P (Olsen) (ppm)	Soil pH
Ordinary Superphosphate	200	9	4.4
	1,000	46	4.5
	2,000	91	4.6
Triple Superphosphate	200	7	4.3
	1,000	47	4.4
	2,000	91	4.4
Termofosfato	200	4	5.0
	1,000	29	6.4
	2,000	55	7.3
Hiperfosfato	200	5	4.8
	1,000	14	5.4
	2,000	18	5.5
Araxa Rock Phosphate	200	3	4.4
	1,000	7	4.6
	2,000	9	4.7

Source: Sanchez and Vehara: Phosphorus sources and rates for forage crops, Agronomic-Economic Research on Tropical Soil, Annual Report for 1974, Soil Science Dept. North Carolina State University.

Notes: The Phosphorus Sources Were:

1. Ordinary superphosphate (20% soluble P205).
2. Termofosfato: Araxa rock phosphate heated with MgSiO3 containing 19% total P205 of which 18% P205 is soluble in citric acid, and available in Brasilia.
3. Hiperfosfato: Moroccan rock phosphate containing 30% total P205 of which 24 to 26% P205 is soluble in citric acid. This product is finely ground with 80% finer than 300 mesh and is available in Brasilia.
4. Araxa rock phosphate: a natural rock phosphate found in the Cerrado containing 28 to 30% total P205 of which 5.5% is soluble in citric acid: finely ground with 85% finer than 200 mesh.

Table AII-3-8 CUMULATIVE DRY MATTER BRACHIARIA DECUMBENS FORAGE YIELD FOR 10 CUTS (TO JUNE 1977) AS A FUNCTION OF SOURCE AND LEVEL OF P FOR 3 LIME RATES. THE SOIL AL SATURATION IS SHOWN AS SAMPLED JUNE 1977. DARK RED LATOSOL. CPAC.

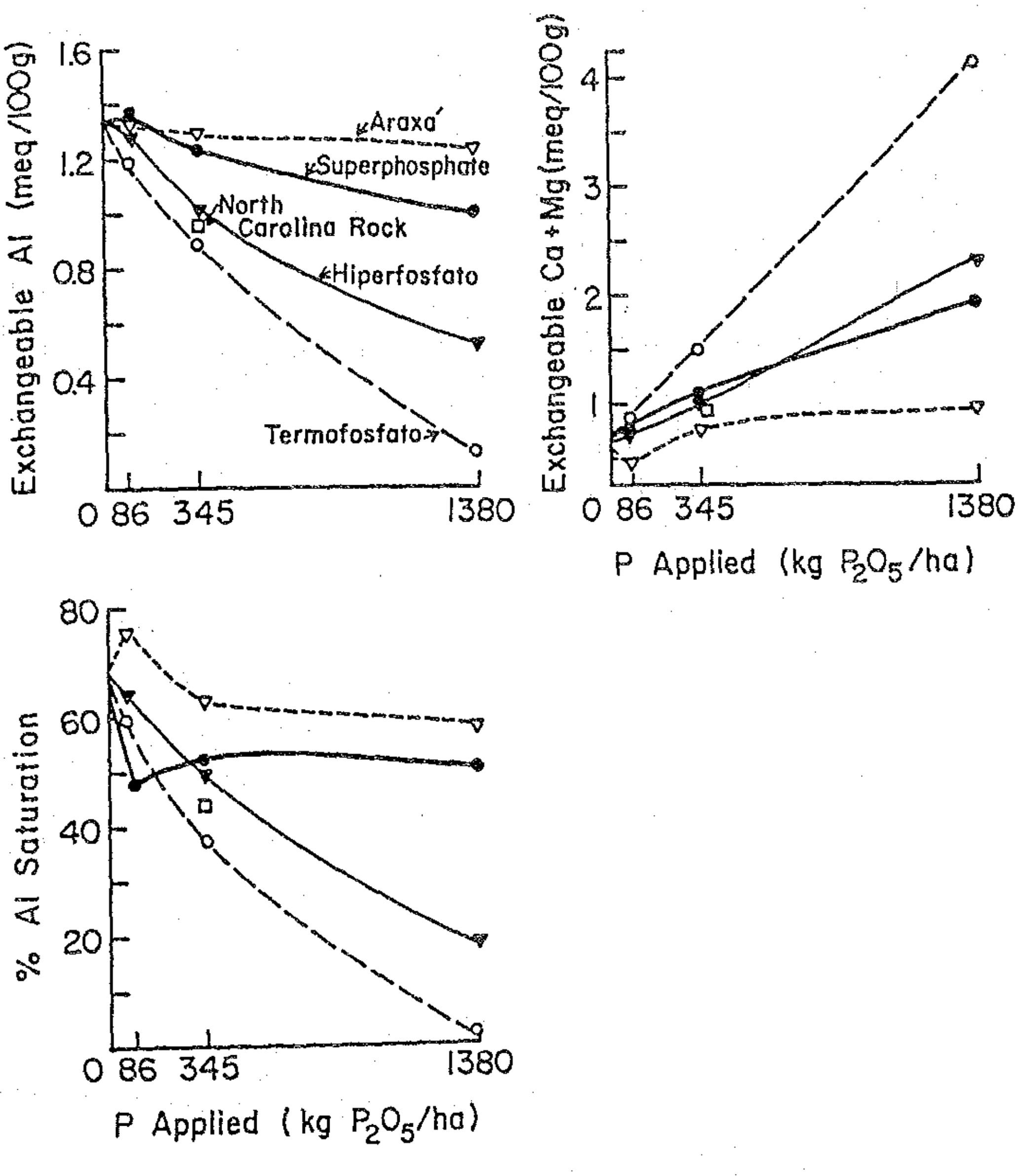
Phosphorus		Soil Al Saturation			Forage Dry Matter			
		Lime (t/ha)			Lime (t/ha)			Means
Source	Rate (Kg/ha)	0	3.0 (%)	4.5	0	3.0 (t/ha)	4.5	
Superphosphate	37	77	57	21	18.1	14.8	17.8	16.9
	150	83	42	26	37.9	38.8	37.4	38.0
	600	80	32	15	43.8	46.0	48.4	46.1
Means					33.3	33.2	34.6	
Termofosfato*	37	76	31	17	11.1	13.0	24.4	16.2
	150	65	25	7	37.6	35.5	38.7	37.3
	600	30	0	0	47.8	46.0	47.7	47.2
Means					32.2	31.5	37.0	
Araxa Rock	37	78	50	22	4.3	9.3	11.4	8.3
	150	82	38	21	26.1	26.1	23.9	25.4
	600	82	28	12	37.8	39.8	40.2	39.3
Means					22.7	25.1	25.1	
Hiperfosfato**	37	78	48	18	14.2	15.6	14.9	14.9
	150	79	37	13	35.7	39.1	38.4	37.7
	600	52	11	5	40.0	46.7	44.0	44.2
Means					30.6	33.8	32.5	
SSP	112+	77	51	23	30.6	35.1	35.6	33.8
Control	0	79	42	16	7.5	6.3	9.4	7.7

Souce: Agronomic - Economic Research on Tropical Soil, Annual Report 1978 to 1979, Soil Science Dept. North Carolina State University.

Notes: * Rock P. fused with $MgSiO_4$ ** Treated Moroccan Rock P

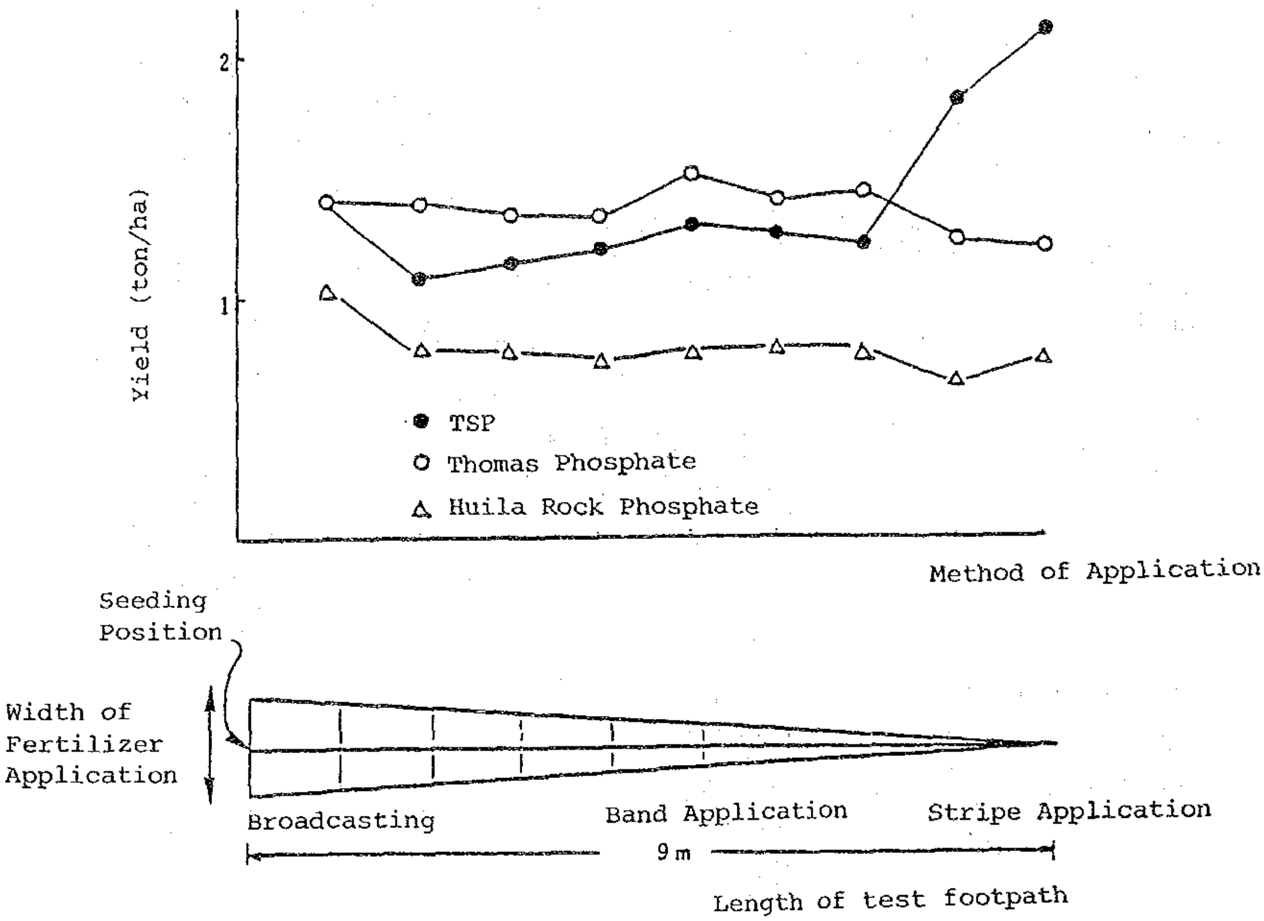
1. + Surface applied as 37Kg of P/ha on Oct. 1974, Nov. 1975 and Nov. 1976.
2. Cutting: May. Dec. (1974) Mar. Aug. Dec. (1975) Mar. May. Nov. (1976) Feb. June (1977)
3. 37KgP/ha = 86Kg P_2O_5/ha, 150KgP = 345KgP_2O_5, 600KgP = 1,380KgP_2O_5
4. Urea was applied periodically on the grass experiment.

Figure AII-3-1 EFFECTS OF PHOSPHORUS SOURCES AND RATES ON THE EXCHANGEABLE CATIONS AND PERCENT ALUMINUM SATURATION OF UNLIMED SOILS THREE MONTHS AFTER PLANTING BRACHIARIA DECUMBENS



Source: Agronomic-Economic Research on Tropical Soil, Annual Report for 1974, Soil Science Dept., North Carolina State University

Figure AII-3-2 YIELD OF KIDNEY BEAN AND METHOD OF PHOSPHATE FERTILIZER APPLICATION



Notes: 1. Fertilizer was applied on the 9m long test footpath, varying the width of fertilizer application from broadcasting to stripe application.

2. Strong acidic volcanic ash soil with high phosphate absorption coefficient. (Colombia)

Source: CIAT "Annual Report, 1977"

Annex II-4

MODIFICATION OF NPK GRADE OF COMPOUND FERTILIZER TO INTRODUCE FMP/SSP

In order to introduce the FMP/SSP into the market, the NPK grades of presently used compound fertilizers are necessary to be modified.

In the case of introduction of FMP, a certain percent of total phosphate is supplied by FMP as a straight fertilizer, and therefore, the rate of P_2O_5 included are necessary to be reduced. With respect to the introduction of SSP, it has to be formulated into the compound fertilizer with remainder supplied by imported phosphate materials such as DAP and/or TSP (Table AII-4-1).

For the estimation purpose of salable prices of FMP and SSP, the NPK grades of such compound fertilizers were calculated as shown in Tables AII-4-2 and 3. It should be noted that this trial calculation does not take into account the easiness of formulation at the actural process. The followings are the conditions taken into consideration in the calculation:

a) One third of phosphate requirement is supplied either by FMP or SSP. In the case of FMP, the FMP is used as a straight fertilizer, whereas the SSP is formulated into a compound fertilizer.

b) 25 percent of total nitrogen contained in the compound fertilizer is in the form of nitrate nitrogen, while remaining 75% in ammoniac nitrogen.

c) All of the potassium is supplied in potassium sulphate.

d) The N-P-K ratio is set as same as that of the present compound "D", including the phosphate contents included in FMP.

e) The total contnets of N, P_2O_5 and K_2O are tried to make as highest possible, to minimize the transportation cost for distribution.

Table AII-4-1 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 AII-4-2 RAW MATERIAL CONSUMPTION AND CONTAINED NUTRIENTS
- CX-DF 12-16-12-10.6 -

Raw Materials					Required Volume (Kg/ton)	Nutrients (%)					
	Nutrient Contents (%)										
	N	P205	K20	S		TN	(AN)	(NN)	WP	WK	S
AN	34	0	0	0	177	60.18	30.09	30.09	-	-	-
AS	21	0	0	24	235	49.35	49.35	-	-	-	56.40
DAP	18	46	0	2.4	59	10.62	10.62	-	27.14	-	1.41
TSP	0	46	0	2	289	-	-	-	132.94	-	5.79
SOP	0	0	50	18	240	-	-	-	-	120.00	43.2
Total					1,000	120.15	90.06	30.09	160.08	120.00	106.8
In %					100	12	9	3	16	12	10.6

Table AII-4-3 RAW MATERIAL CONSUMPTION AND CONTAINED NUTRIENTS
- CX-DS 9-18-9-9.5 -

Raw Materials					Required Volume (Kg/ton)	Nutrients (%)					
	Nutrient Contents (%)					TN	(AN)	(NN)	WP	WK	S
	N	P205	K20	S							
AN	34	0	0	0	133	45.22	22.61	22.61	-	-	-
AS	21	0	0	24	75	15.05	15.75	-	-	-	18.00
DAP	18	46	0	2.4	162	29.16	29.16	-	74.52	-	3.88
TSP	0	46	0	2	99	-	-	-	45.54	-	1.98
SSP	0	17.2	0	111	350	-	-	-	60.2	-	38.85
SOP	0	0	50	18	181	-	-	-	-	90.50	32.58
Total					1,000	90.13	67.52	22.61	180.26	90.50	95.29
In %					100	9	6.7	2.2	18	9	9.5

INTERNATIONAL MARKET PRICE OF PHOSPHATE FERTILIZER

(1) Demand for Phosphate Fertilizer in the World

Table AII-5-1 shows the demand for phosphate fertilizer in the world by region. Of the total phosphate fertilizer consumed in the world, 30% was consumed in West Europe and North America, while 29% was consumed in East Europe. The ratio of volume of phosphate fertilizer consumption to that of nitrogen fertilizer was around 0.5 on the average in the world. It is due to the fact that the effect of nitrogen fertilizer application on crop yield is more easily observed than that of phosphate fertilizer in general, and therefore, the nitrogen fertilizer is firstly introduced at the earlier stage of fertilizer utilization.

Nevertheless, the consumption of phosphate fertilzer is much higher than that of nitrogen fertilizer in some countries in South America and Oceania, where a large quantity of phosphate fertilizer is applied on pasture on phosphate deficient soils.

Table AII-5-2 gives the outlook of supply/demand balance of phosphate fertilizer in the world, which was projected by Fertilizer Working Group of FAO/UNIDO/World Bank. According to this projection, the world demand for phosphate fertilizer is expected to increase by 2.65% annually on the average in 6 years from 1984 through 1990 (Table AII-5-3). Compared with the annual increase rate in the past as shown in Table AII-5-4, the demand increase is projected to stagnate slightly in the future. Actually, in the developed countries, the increase in the cropped area may be limited in the future, and, at the same time, the dose level of fertilizer is already high with remaining only little potentiality for further increase in the dose level (Table AII-5-5). Thus, the future increase in the demand for fertilizer will not be large. However, in the developing countries, where the increase in food production is essential, the increase in the demand for phosphate fertilizer is expected to continue. The average annual increase rate in these countries are projected to be 4.83% in Asia, 2.40% in East Europe, and 3.44% in South America.

(2) Supply of Phosphate Fertilizer in the World

Of the phosphate supplied in the world, 99% has been obtained from phosphate rock, and the remaining 1% was recovered from iron ore.

Table AII-5-6 shows the past trend of phosphate rock production in the world by major producing country. Of the world production of phosphate rock in 1983, 68% was produced by the U.S.A., Morocco, and the U.S.S.R. In the second half of 1950s, these three countries accounted for 77% of world production, but this ratio has decreased due to the increase in the production by such countries as Jordan and African countries other than Morocco.

The world demand for phosphate fertilizer is expected to increase to 41.9 million P_2O_5 tons in 1990.

Adding the industrial demand and distribution/production loss to the above demand, more than 51.4 million P_2O_5 tons of phosphate rock will be required in 1990.

However, according to the survey carried out by IFA (International Fertilizer Association), 58.9 million P_2O_5 tons of phosphate rock production is expected in 1990, and therefore, the oversupply situation is projected in the world phosphate rock market for coming 5 years period (Table AII-5-7).

The phosphate fertilizer is produced from phosphate rock, but it is rare for the phosphate rock itself to be applied directly on crops. The phosphate rock is used as a raw material, mainly processed into phosphoric acid (except for the case of SSP production), and further converted to such final products of phosphate fertilizer as ammonium phosphate, TSP and compound fertilizers. The phosphate materials are traded not only as raw materials of final products, but also as intermediate products. Table AII-5-8 shows the world phosphate fertilizer trade by type of material. In 1975, 85% of 17.4 million P_2O_5 tons of world phosphate was traded in phosphate rock, but the ratio has decreased to 69% of 20.6 million P_2O_5 tons in 1982 due to the increase in the trade in phosphoric acid.

In 1950s and the early 1960s, the cheaper ocean freight rates made the trade of phosphate rock viable, and the production facilities of phosphoric acid and phosphate fertilizers were built in the consumer countries in West Europe based on the imported phosphate rock. The producers in these countries viewd with others in expanding the production capacities to receive the benefits from scale economies. The residuals of products after absorbed in the domestic market, were re-exported in the form of final products. The production capacity of these facilities were further expanded to compete with other exporters when the supply exceeded the demand in the late 1960s. However, since the latter half of 1960s, the producer countries of phosphate rock, especially that of developing countries started production of phosphoric acid and phosphate fertilizers for export, by large scale production facilities to increase the value added of their phosphate rock. The ocean freight rates and energy costs as well as the price of sulphur, which is one of the major raw materials for phosphoric acid, also increased. As a result, the producing countries in West Europe, whose production was based on the imported phosphate rock, and oriented for export, lost their competitiveness in the export market, and major exporters of phosphate intermediates as well as final products have shifted to the phosphate rock producing countries.

(3) International Market Price of Phosphate Fertilizer

The main exporter country of phosphate rock in the international market was the U.S.A. in 1950s. The U.S.A. posted the market price and other producers including Morocco followed the price, and thus the international market price was formulated with the U.S.A. regarded as the price leader of the market. However, after the outbreak of first oil crisis in 1973, Morocco and the African/Mideastern producing countries increased the price by 4 to 5 times in order to achieve the leading position in the market, following the OPEC's position in the oil market. The U.S.A. also followed the Morocco's price hike, and the U.S.A.'s position in the market was seemed to be replaced by Morocco.

However, such price increase caused the stagnation in the demand, and Morocco lost its market greatly. Nevertheless, the U.S.A. could keep its market without decline in the shipment, and thus Morocco was forced to ease up their intention to establish their leading position in the market. At present, the price at U.S. Gulf is regarded as the indicative price in the international market for phosphate rock, phosphoric acid and phosphate fertilizers.

Among the various phosphate products/intermediates/raw materials, the price of DAP may be regarded as the representative price due to the fact that firstly, DAP is the representative phosphate fertilizer in view of traded volume, and secondly, DAP is traded in spot market, whereas phosphoric acid and phosphate rock is traded mainly by long term contract.

The price of DAP has affected by the following three factors;

1. Long term decline caused by decrease in the production cost in constant price basis. This cost decrease was the result of improvement in the technology including energy saving and raw material saving as well as the result of scale of economies.
2. Change in energy costs.
3. The supply/demand situation in the market.

In addition to the above factors, the cost of sulphur and cost of phosphate rock will excert the influences on the market price of phosphate fertilizers in case these costs increase significantly compared with the past trend of the prices of these materials due to, for example, increase in the mining costs, etc. However, in the foreseeable future, there is no possibility of such increase in the costs of phosphate rock and sulphur.

In the case of sulphur, the supply in the western world has showed deficit and the requirement has met by the supply from the socialist world. In the future, the deficit will be increased, and it has to be met by extraction from the stocks in addition to the supply from the socialist world. Thus, the balance is estimated to continue to be tight, nevertheless, such tight market will not result in the development of new and costly mining. Thus, the mining cost of sulphur will not be increased significantly.

In the case of phosphate rock, as shown Figure AII-5-1, the mining cost level will not change significantly in the foreseeable future.

Thus, the future price of DAP may be explained mostly by the three factors described above.

Table AII-5-9 presents the result of regression of DAP prices by these factors with the projection using the regression result. According to the result, the regression was highly significant in terms of various statistical indicators.

The prices of other phosphate fertilizers have changed in accordance with the change in the price of DAP with slight deviation reflecting the market situation of each product time to time.

In the case of TSP, the price has been 0.72 times of that of DAP with the range being ±0.05. The major factor for the deviation may be attributable to the fact that major DAP producers are the ammonia producers at the same time. They can decrease the price of DAP in case of keen competition in the phosphate fertilizer market under the normal or favorable nitrogen market.

The price of compound fertilizer has been 0.89 times that of DAP price with the range of ±0.08. However, this price may be applicable to the main grade of compound fertilizers traded in the international market. Compound fertilizer is generally produced for domestic consumption, and the suppliers export it when supply exceeds the consumption. Under such condition, the price of compound fertilizer has depressed compared with the above price trend. However, on the other hand, in the case of the grades which are not traded in the international market, the production is for the purpose of the specific trade, and therefore, the price of such grade tends to be more expensive than the widely traded grades, unless these grades are exported to despose of the accumulated stocks.

The price of compound fertilizer is not necessarily proportinate to the total contents of N, P2O5 and K2O. The content of 45% formulates the base price with the price per unit content of nutrient increases in the case of other grades.

Table AII-5-9 shows the projected prices of TSP and compound fertilizers based on the price formulation trend described above.

Notes: The international prices of nitrogen and potassium fertilizers were also projected by the regression with the three affecting factors as the independent variables in the regression. Urea is the representative fertilizer in the case of nitrogen fertilizer, and MOP in the case of potassium fertilizer. The regression results are given in Tables AII-5-11 and 12, respectively, and the projected landed costs of fertilizers in Zambia are summarized in Table AII-5-10.

Table AII-5-1 PRODUCTION AND CONSUMPTION OF FERTILIZER IN THE WORLD, 1984

(Unit: Million ton)

	N	P205	K20	Total
Production				
Developed Market Economies	27.45	17.98	15.22	60.65
N. America	13.66	10.32	8.57	32.55
W. Europe	11.75	5.46	5.49	22.70
Oceania	0.27	0.94	0.00	1.21
Others	1.76	1.26	1.17	4.19
Developing Market Economies	13.76	6.59	0.29	20.65
Africa	0.34	0.99	0.00	1.33
L. America	2.62	1.83	0.00	4.45
Near East	3.24	1.24	0.29	4.77
Far East	7.57	2.49	0.00	10.05
Centrally Planned Economies	33.05	12.45	13.27	58.77
Asia	13.05	2.59	0.03	15.67
Europe & USSR	20.00	9.86	13.24	43.10
World	74.26	37.03	28.78	140.07
Consumption				
Developed Market Economies	23.75	12.59	12.00	48.35
N. America	11.69	4.94	5.40	22.03
W. Europe	10.54	5.34	5.34	21.42
Oceania	0.36	1.11	0.28	1.75
Other	1.15	1.21	0.79	3.15
Developing Market Economies	15.82	7.86	3.73	27.41
Africa	0.70	0.52	0.25	1.47
L. America	3.21	2.49	1.68	7.38
Near East	2.61	1.53	0.10	4.24
Far East	9.28	3.33	1.69	14.30
Centrally Planned Economies	30.94	13.82	10.16	54.91
Asia	16.00	4.07	0.91	20.98
Europe & USSR	14.94	9.75	9.25	33.94
World	70.51	34.27	25.89	130.67

Source: FAO/UNIDO/World Bank Working Group of Fertilizers, 1986.

Table AII-5-2 PROJECTED BALANCE BETWEEN SUPPLY AND DEMAND OF PHOSPHATE FERTILIZER

(Unit: Million P205 ton)

	1986	1988	1990
Production			
Developed Market Economies	7.77	7.78	7.29
N. America	6.15	6.26	5.92
W. Europe	0.72	0.68	0.61
Oceania	0.28	0.27	0.24
Other	0.62	0.57	0.52
Developing Market Economies	-0.09	0.31	-0.37
Africa	2.43	3.22	3.31
L. America	-0.64	-0.76	-0.93
Near East	-0.06	-0.06	-0.32
Far East	-1.83	-2.09	-2.42
Centrally Planned Economies	-2.58	-3.10	-3.66
Asia	-1.37	-1.88	-2.16
Europe & USSR	-1.21	-1.22	-1.50
World	5.09	4.99	3.27

Source: FAO/UNIDO/World Bank Working Group of Fertilizers, 1986.

Table AII-5-3 PROJECTED ANNUAL GROWTH RATE OF FERTILIZER DEMAND IN THE WORLD - 1984-1990 -

(Unit: %)

	N	P205	K20
Production			
Developed Market Economies	0.61	0.39	0.76
N. America	-0.09	-0.07	0.73
W. Europe	1.24	0.49	0.65
Oceania	2.19	1.59	2.25
Other	1.12	0.68	1.23
Developing Market Economies	5.83	5.04	4.76
Africa	6.91	6.29	5.57
L. America	6.15	3.44	4.09
Near East	3.93	4.30	8.89
Far East	6.14	6.28	5.04
Centrally Planned Economies	2.65	3.14	4.06
Asia	1.31	4.83	5.99
Europe & USSR	4.00	2.40	3.86
World	2.77	2.65	3.26

Source: FAO/UNIDO/World Bank Working Group of Fertilizers, 1986.

Table AII-5-4 ANNUAL GROWTH RATE OF FERTILIZER CONSUMPTION IN THE WORLD

(Unit: %)

	1974-79	1975-80	1976-81	1977-82	1978-83	1979-84
Developed Market Economies						
N	5.8	3.5	2.1	1.0	1.2	0.8
P205	3.9	2.0	-1.0	-1.8	-1.6	-2.1
K20	5.0	4.0	0.1	-0.7	-0.6	-1.1
Total	5.0	3.0	0.7	-0.2	-0.1	-0.5
Developing Market Economies						
N	10.5	10.3	8.5	7.0	5.8	5.9
P205	10.5	11.4	6.0	4.7	2.6	4.8
K20	9.5	13.8	6.8	3.0	0.7	3.3
Total	10.4	11.1	7.5	5.8	4.2	5.2
Centrally Planned Economies						
N	9.3	8.4	8.7	6.5	4.9	4.8
P205	4.8	3.9	4.8	3.5	4.9	4.1
K20	1.5	-1.1	-0.2	0.0	2.2	3.7
Total	6.4	5.1	5.6	4.3	4.4	4.4
World Total						
N	8.1	6.7	5.9	4.5	3.7	3.6
P205	5.3	4.3	2.4	1.5	1.6	1.7
K20	4.2	2.6	0.7	0.0	1.7	1.2
Total	6.4	5.1	3.8	2.7	2.5	2.6

Source: FAO/UNIDO/World Bank Working Group of Fertilizers, 1986.

Table AII-5-5 FERTILIZER CONSUMPTION PER HECTARE OF ARABLE LAND

(Unit: kg)

	1970				1984			
	N	P205	K20	Total	N	P205	K20	Total
Developed Market Economies	58	36	32	126	58	33	31	122
N. America	48	24	25	97	48	22	24	93
W. Europe	105	64	59	228	109	57	58	224
Oceania	6	29	5	40	7	25	6	38
Other	64	69	47	180	59	62	41	162
Developing Market Economies	16	9	5	30	21	10	4	35
Africa	4	3	1	8	4	4	2	10
L. America	16	15	9	40	15	10	7	32
Near East	20	12	1	33	34	18	1	54
Far East	23	7	5	35	31	10	5	46
Centrally Planned Economies	59	28	21	108	76	34	26	136
Asia	99	19	5	123	128	34	8	170
Europe & USSR	43	31	28	102	54	34	33	122
World	39	21	16	77	46	22	17	85

Source: FAO/UNIDO/World Bankking Grof Fertils, 1986.

Table AII-5-6 PRODUCTION OF PHOSPHATE ROCK IN THE WORLD BY MAJOR PRODUCING COUNTRIES

(Unit: '000 tons of Phosphate rock)

	1958*2	1965*3	1970*3	1975*3	1980*3	1983*3
USA	15,117.1 (42.5)*1	26,745.5 (49.3)	35,143.2 (43.4)	44,284.0 (41.0)	53,363.0 (39.6)	41,890.0 (31.8)
Morocco	6,335.5 (17.8)*1	9,225.0 (17.0)	11,399.0 (14.1)	14,119.0 (13.1)	18,824.0 (14.0)	19,842.0 (15.0)
Tunisia	2,278.4	3,040.9	3,024.0	3,512.0	4,502.0	5,924.0
Togo	-	812.6	1,508.0	1,100.0	2,933.0	2,081.0
Senegal	-	1,038.3	3,024.0	1,978.0	1,459.0	1,250.0
Jordan	293.9	827.9	891.0	1,353.0	3,911.0	4,746.0
Nauru Is.	1,254.3	1,550.0	2,114.0	1,534.0	2,087.0	1,684.0
Christmas Is.	379.7	1,118.0	1,003.0	1,003.0	1,438.0	1,095.0
USSR	6,004.6 (16.9)*1	6,700.0 (12.0)	17,920.0 (22.2)	24,150.0 (22.4)	26,100.0 (19.4)	27,700.0 (21.0)
Others	3,896.5	3,241.8	4,873.8	14,892.0	20,235.0	25,711.0
World Total	35,560.0	54,300.0	80,900.0	107,925.0	134,852.0	131,923.0

Note: *1 Figures in parentheses show the percentage of world total.

Sources: *2 United Kingdom, Overseas Geological Survey, "Statistical Summary of the Mineral Industry", (London: 1965).
*3 FAO, "Annual Fertilizer Review".

Table AII-5-7 PROJECTED SUPPLY/DEMAND BALANCE OF PHOSPHATE ROCK IN 1990

(P205 '000 ton)

	Phosphate Fertilizer Consumption (A)	Basic Slag Production (B)	Technical Use of Phosphate Rock (C)	Phosphate Rock Supply (D)	Balance (E)
W. Europe	5,301	200	1,600	293	-7,078
E. Europe	11,775	50	1,025	11,349	-2,676
N. America	5,135	3	1,400	16,836	9,651
L. America	3,113	9	200	1,949	-1,685
N. East	2,310	0	10	5794	3,242
Africa	1,160	0	88	17,044	15,672
Asia	6,201	0	685	287	-7,288
Soc. Asia	5,677	0	40	4,385	-1,904
Oceania	1,185	1	50	996	-362
World	41,857	263	5,098	58,933	7,572

Note: (D) - [(A) - (B) + (C)] x 1.1 = (E)
Loss is assumed 10% of total demand.

Souce: IFA

Table AII-5-8 TRADE OF PHOSPHATE FERTILIZER BY TYPE OF FERTILIZER

(Unit: '000 P205 ton)

	1975					1982				
	P-Rock*1	P-Acid	DAP	TSP	Total	P-Rock*1	P-Acid	MAP/DAP	TSP	Total
Export										
W. Europe	8	275	99	102	484	-	353	-	183	536
E. Europe	1,906	-	-	-	1,906	1,699	-	221	-	1,920
Africa	6,672	98	-	110	6,880	6,295	1,252	244	355	8,146
N. America	3,715	241	1,333	448	5,737	3,228	907	1,899	490	6,524
C. America	17	215*2	-	10	242	-	-	-	-	-
S. America	-	-	-	-	-	-	69	-	-	69
Asia	1,339	-	-	-	1,339	1,758	76	179	105	2,118
Oceania	695	-	-	-	695	-	-	-	-	-
World	14,352	827	1,476	724	17,379	14,230	2,657	2,543	1,134	20,564
			(44)*4	(54)*4		(1,250)*4				
Import										
W. Europe	6,326	261	339	136	7,062	5,900	695	795	347	7,737
E. Europe	3,182	42	2	97	3,323	3,461	643	56	194	4,354
Africa	16	0	31	12	59	11	0	79	8	98
N. America	1,059	57	219	18	1,353	788	32	292	23	1,135
C. America	418	22*2	54	9	503	358	38	147	81	624
S. America	339	238	265	210	1,052	110	302	159	66	637
Asia	2,005	200	536	192	2,933	2,548	947	916	374	4,785
Oceania	1,006	3	9	0	1,018	981	0	72	5	1,058
World	14,352	827	1,476	724	17,379	14,230	2,657	2,543	1,134	20,564
		(7)*3	(22)*3	(50)*3		(74)*3		(27)*3	(38)*3	

Notes: *1 Calculated as 32.5% P205.
*2 Including Brazil.
*3 Volume destined to unknown countries, and included in the world total.
*4 Volume exported from unspecified countries, and included in the world total.

Source: IFA

Table AII-5-9 ANALYSIS AND PROJECTION OF INTERNATIONAL PRICE OF DAP

Year	Prices of DAP				Independent Variables		
	Current Actual (A)	Current Proj'n (B)	Modifc'n Factor (C)	Revised Proj'n (D)	Year '61=1 (E)	Crude Oil Price (F)	MUV '85=100 (G)
1967	68.5	70.4	0.97	68.3	7	1.8	33.2
1968	65.5	65.9	0.99	65.2	8	1.8	32.9
1969	58.0	66.5	0.87	57.9	9	1.8	34.6
1970	54.0	68.4	0.79	54.0	10	1.8	36.9
1971	61.8	71.0	0.87	61.8	11	2.2	38.9
1972	91.0	75.9	1.20	91.1	12	2.5	42.2
1973	118.8	89.0	1.33	118.4	13	3.3	49.0
1974	332.6	118.5	2.81	333.0	14	9.6	59.7
1975	243.0	130.5	1.86	242.7	15	10.5	66.3
1976	120.0	130.3	0.92	119.9	16	11.5	67.3
1977	133.0	142.1	0.94	133.6	17	12.4	73.9
1978	139.8	162.5	0.86	139.8	18	12.7	85.0
1979	193.3	187.9	1.03	193.5	19	17.3	96.3
1980	222.2	214.0	1.04	222.6	20	29.4	105.6
1981	195.0	212.0	0.92	195.0	21	33.2	105.6
1982	182.8	203.0	0.90	182.7	22	34.0	103.1
1983	183.5	194.0	0.95	184.3	23	29.5	101.8
1984	189.1	186.6	1.01	188.5	24	29.0	100.0
1985	168.5	183.0	0.92	168.4	25	28.1	100.0
1986		170.1	0.85	144.6	26	15.0	100.0
1987		175.0	0.95	166.3	27	16.5	103.0
1988		182.7	0.95	173.6	28	21.0	106.1
1989		186.6	1.00	186.6	29	21.0	109.3
1990		190.9	1.00	190.9	30	21.2	112.6
1991		195.5	1.00	195.5	31	21.7	116.0
1996		222.4	1.00	222.4	36	24.8	119.5

Notes:
1. (D) = (B) x (C)
   Where, (C) represents the influence from supply and demand situation in the market. Until 1985, (C) = (A) / (B)
2. Price is in FOB U.S. Gulf, bulk.
3. (F): Crude oil price. Arabian Light, FOB origin.
   Up to 1985 = Actual.
   1986 - 1996 = Projected, in 1985 price.
4. (G): Manufacturing unit value of internationally traded goods.
   1985 = 100
   Assumed to increase at 3% p.a. after 1987.

Table AII-5-10 INTERNATIONAL MARKET PRICES AND LANDED COST OF FERTILIZER AND RAW MATERIALS

(Unit: US$/ton)

		DAP	TSP *5	Urea	AS *6	AN *7	MOP	SOP *8	CX 45%	CX 40% *9	CX 36% *10
FOB Origin*1	(1)	194	140	125	60	111	89	223	173	163	156
Freight to Dar es Salaam	(2)	36	36	36	34	34	31	36	34	34	134
C&F Dar es Salaam	(3)=(1)+(2)	230	176	151	94	145	120	259	207	197	190
Charges at Port*2	(4)	43	43	43	21	21	43	43	21	21	21
Insurance	(5)=(3)x2.5%	6	4	4	3	4	3	6	5	5	5
Inland Freight*3	(6)	63	63	63	63	63	63	63	63	63	63
Landed Cost	(3)+(4)+(5)+(6)	342	286	261	181	233	229	371	296	286	279
In Kwacha Equivalent*4		2,736	2,288	2,088	1,448	1,864	1,832	2,968	2,368	2,288	2,232

Notes: *1 See Tables AII-5-9, AII-5-11 AND AII-5-12.
Assumptions on the projected prices are as follows:
1. Average prices in the period 1991 through 1996 at 1991 price assuming 3% of annual price escalation in the future.
2. The price of crude oil (Arabian Light) is assumed US$21.7 per bbl in 1991, increasing to US$24.8 per bbl in 1996 at 1985 price.

DAP/TSP/Urea/SOP: f.o.b. U.S.Gulf, bulk
MOP: f.o.b. Vancouver, bulk
CX: f.o.b. Northwest Europe, bagged

*2 Bagging charge US$20/ton, and other charges US$18/ton in January 1987, with further increase in the rate at 3.0% p.a.

*3 By rail. Assuming US$55/ton in January 1987, with further increase in the rate at 3.0% p.a.

*4 US$1.00 = K.8.00

*5 (TSP fob price) = (DAP fob price) x 0.72

*6 (AS fob price) = (Urea fob price) x 0.89

*7 (AN 34% fob price) = (Urea fob price) x 34/46 x 1.2

*8 (SOP fob price) = (MOP fob price) x 2.50

*9 (CX 40% fob price) = (CX 45% fob price) x 1/45 x (40+45) / 2

*10 (CX 36% fob price) = (CX 45% fob price) x 1/45 x (36+45) / 2

Table AII-5-11 ANALYSIS AND PROJECTION OF INTERNATIONAL PRICE OF UREA

Year	Prices of Urea				Independent Variables		
	Current Actual (A)	Current Proj'n (B)	Modifc'n Factor (D)	Revised Proj'n (C)	Year '61=1 (E)	Crude Oil Price (F)	MUV '85=100 (G)
1967	79.3	81.3	0.98	79.7	7	1.8	33.2
1968	65.5	65.1	1.01	65.8	8	1.8	32.9
1969	56.0	59.3	0.94	55.7	9	1.8	34.6
1970	48.3	56.4	0.86	48.5	10	1.8	36.9
1971	46.0	55.7	0.83	46.2	11	2.2	38.9
1972	59.3	57.8	1.03	59.5	12	2.5	42.2
1973	94.8	70.4	1.35	95.0	13	3.3	49.0
1974	315.8	111.7	2.83	316.1	14	9.6	59.7
1975	198.0	123.0	1.61	198.0	15	10.5	66.3
1976	112.0	116.5	0.96	111.8	16	11.5	67.3
1977	127.4	127.0	1.00	127.0	17	12.4	73.9
1978	144.8	149.3	0.97	144.8	18	12.7	85.0
1979	172.9	182.6	0.95	173.5	19	17.3	96.3
1980	222.1	222.3	1.00	222.3	20	29.4	105.6
1981	216.0	211.7	1.02	215.9	21	33.2	105.6
1982	158.8	190.0	0.84	159.6	22	34.0	103.1
1983	135.4	168.2	0.80	134.6	23	29.5	101.8
1984	171.3	152.1	1.13	171.9	24	29.0	100.0
1985	142.1	141.8	1.00	141.8	25	28.1	100.0
1986		116.5	0.95	110.7	26	15.0	100.0
1987		118.9	1.00	118.9	27	16.5	103.0
1988		125.6	1.00	125.6	28	21.0	106.1
1989		126.2	1.00	126.2	29	21.0	109.3
1990		127.2	1.00	127.2	30	21.2	112.6
1991		128.6	1.00	128.6	31	21.7	116.0
1996		140.5	1.00	140.5	36	24.8	119.5

Notes: 1. (D) = (B) x (C)
Where, (C) represents the influence from supply and demand situation in the market. Until 1985, (C) = (A) / (B)

2. Price is in FOB U.S. Gulf, bulk.

3. (F): Crude oil price, Arabian Light, FOB origin.
Up to 1985 = Actual.
1986 - 1996 = Projected, in 1985 price.

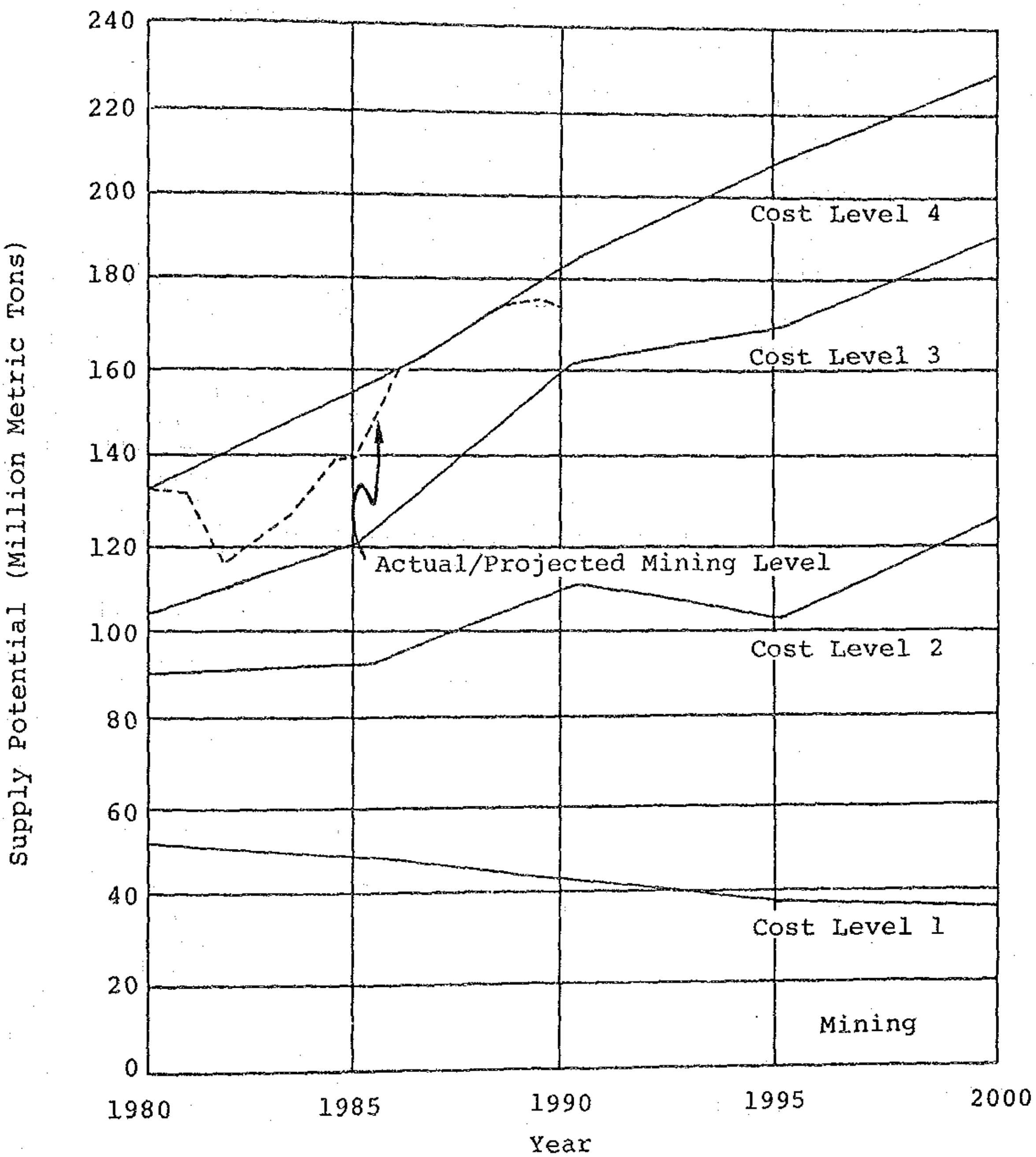
4. (G): Manufacturing unit value of internationally traded goods.
1985 = 100
Assumed to increase at 3% p.a. after 1987.

Table AII-5-12 ANALYSIS AND PROJECTION OF INTERNATIONAL PRICE OF MOP

Year	Prices of MOP				Independent Variables		
	Current Actual (A)	Current Proj'n (B)	Modifc'n Factor (D)	Revised Proj'n (C)	Year '61=1 (E)	Crude Oil Price (F)	MUV '85=100 (G)
1967	25.5	27.4	0.93	25.5	7	1.8	33.2
1968	24.0	26.8	0.90	24.1	8	1.8	32.9
1969	22.0	27.2	0.81	22.0	9	1.8	34.6
1970	31.5	27.9	1.13	31.5	10	1.8	36.9
1971	32.5	29.8	1.09	32.5	11	2.2	38.9
1972	33.5	31.9	1.05	33.5	12	2.5	42.2
1973	42.5	36.9	1.15	42.4	13	3.3	49.0
1974	60.5	53.2	1.14	60.6	14	9.6	59.7
1975	81.3	57.3	1.42	81.4	15	10.5	66.3
1976	55.0	58.6	0.94	55.1	16	11.5	67.3
1977	51.0	62.6	0.81	50.7	17	12.4	73.9
1978	56.4	67.9	0.83	56.4	18	12.7	85.0
1979	76.7	78.2	0.98	76.6	19	17.3	96.3
1980	115.7	93.3	1.24	115.7	20	29.4	105.6
1981	112.4	95.5	1.18	112.7	21	33.2	105.6
1982	81.6	94.2	0.87	82.0	22	34.0	103.1
1983	75.3	89.8	0.84	75.4	23	29.5	101.8
1984	83.7	88.0	0.95	83.6	24	29.0	100.0
1985	85.2	86.9	0.98	85.2	25	28.1	100.0
1986		74.2	1.00	74.2	26	15.0	100.0
1987		77.5	1.00	77.5	27	16.5	103.0
1988		83.8	1.00	83.8	28	21.0	106.1
1989		85.6	1.00	85.6	29	21.0	109.3
1990		87.5	1.00	87.5	30	21.2	112.6
1991		89.8	1.00	89.8	31	21.7	116.0
1996		102.8	1.00	102.8	36	24.8	119.5

Notes:
1. (D) = (B) x (C)
   Where, (C) represents the influence from supply and demand situation in the market. Until 1985, (C) = (A) / (B)
2. Price is in FOB U.S. Gulf, bulk.
3. (F): Crude oil price. Arabian Light, FOB origin.
   Up to 1985 = Actual.
   1986 - 1996 = Projected, in 1985 price.
4. (G): Manufacturing unit value of internationally traded goods.
   1985 = 100
   Assumed to increase at 3% p.a. after 1987.

Figure AII-5-1 SUPPLY POTENTIAL* OF PHOSPHATE ROCK BY LEVEL OF MINING COSTS



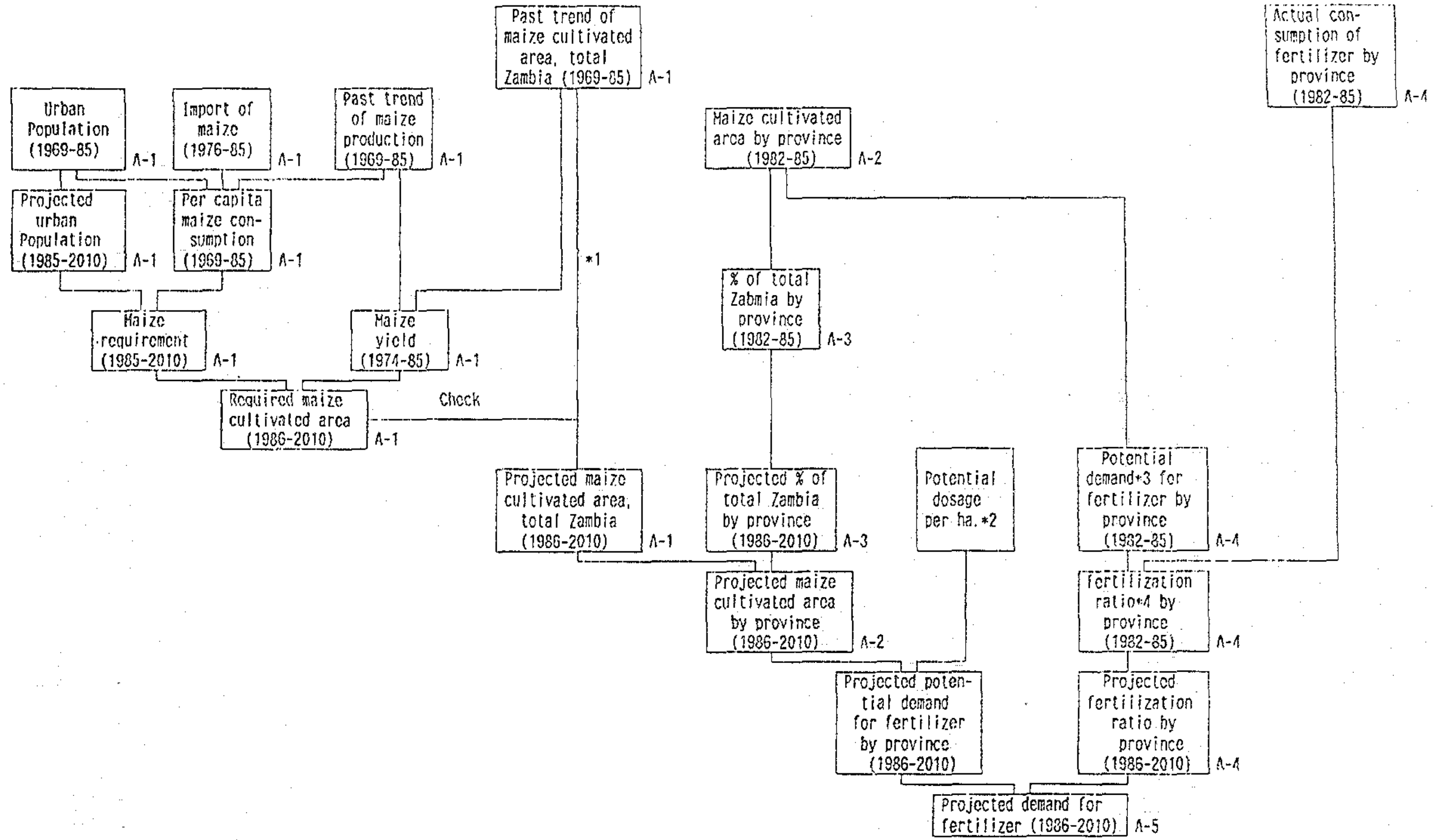
Note: * Excluding China

Source: IFA

Annex II-6

DATA FOR PROJECTION OF FERTILIZER DEMAND

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
*3 Potential dosage (kg/ha) x Cultivated area (ha)
*5 "A-x" means the number of tables attached in Annex II-6.
*2: N 112kg/ha P204 40kg/ha K20 20kg/ha
*4: Actual consumption / Potential demand

Table AII-6-1 ACTUAL/PROJECTED MAIZE CULTIVATED AREA IN ZAMBIA

Year	Total Population (1,000)	Population in Urban Area (1,000)	Maize Marketed Production 1,000 bags	Maize Marketed Production 1,000 ton	Maize Cultivated Area (1,000 ha)	Maize Req'd Cultivated Area (1,000 ha)	Yield of Maize (kg/ha)	Maize Import (1,000 ton)	Maize Export (1,000 ton)	Maize Consumption (1,000 ton)	Maize Per Capita Consumption/Ubn. (kg/year)
Actual											
1963	3489	715									
1969	4057	1193	3044	274.0						274.0	229.7
1971	4386	1399	4444	400.0					0.806	399.2	285.3
1972	4527	1498	6164.6	616.6					0.109	616.5	411.5
1974	4695	1657	6203.0	495.0	194.1	194.1	2550.2		11.004	484.0	292.1
1976	5138	1916	9911.3	746.4	268.1	268.1	2784.0	0.025	0.808	745.6	389.1
1977	5302	2031	10127.4	693.0	485.0	485.0	1428.9	0.401	2.506	690.9	340.2
1978	5425	2160		657.0	595.0	595.0	1104.2	0.022	6.009	651.0	301.4
1979	5550	2296		331.3	335.0	402.2	989.0	66.423	-	397.7	173.2
1980	5679	2442		383.0	540.0	954.9	709.3	294.279	-	677.3	277.4
1981	5888	2609		693.3	493.8	560.4	1404.0	93.526	-	786.8	301.6
1982	6104	2788		508.3	454.5	516.0	1118.4	68.779	-	577.1	207.0
1983	6328	2978		530.6	546.7	676.5	970.6	125.997	-	656.6	220.5
1984	6560	3182		571.2	506.5	506.5	1127.7	-	-	571.2	179.5
1985	6800	3400	12470.8	648.0	581.9	654.8	1113.6	81.137	-	729.1	214.4
Projected											
1986	7009	3595		723	617	813	1171.8	230		953	
1987	7225	3797		771	643	840	1198.3	235		1006	
1988	7448	4006		820	670	867	1224.5	242		1062	
1989	7677	4221		870	696	895	1250.4	249		1119	
1990	7914	4445		923	723	923	1276.1	255		1178	
1991	8157	4674		976	750	952	1301.4	263		1239	
1992	8409	4912		1029	776	982	1326.5	273		1302	
1993	8668	5157		1085	803	1012	1351.3	282		1367	
1994	8935	5410		1141	829	1042	1375.8	293		1434	
1995	9210	5670		1198	856	1073	1400.1	305		1503	
1996	9494	5940		1258	883	1105	1424.2	316		1574	
1997	9786	6218		1316	909	1138	1447.9	332		1648	
1998	10087	6505		1377	936	1172	1471.5	347		1724	
1999	10398	6802		1438	962	1206	1494.8	365		1803	
2000	10718	7107		1501	989	1241	1517.8	382		1883	
2001	11048	7423		1565	1016	1277	1540.7	402		1967	
2002	11389	7749		1629	1042	1313	1563.3	424		2053	
2003	11739	8085		1695	1069	1351	1585.7	448		2143	
2004	12101	8432		1761	1095	1389	1607.8	473		2234	
2005	12474	8790		1829	1122	1429	1629.8	500		2329	
2006	12858	9160		1898	1149	1470	1651.5	529		2427	
2007	13254	9541		1966	1175	1511	1673.1	562		2528	
2008	13662	9934		2037	1202	1554	1694.4	596		2633	
2009	14083	10340		2107	1228	1597	1715.6	633		2740	
2010	14517	10759		2179	1255	1642	1736.5	672		2851	

Table AII-6-2 ACTUAL/PROJECTED MAIZE CULTIVATED AREA BY PROVINCE

(Unit: '000 ha)

	Total (A)	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
======										
1982	454.5	101.0	7.4	196.0	2.9	22.7	24.5	4.2	85.0	10.8
1983	546.7	147.0	7.7	221.0	3.4	25.0	35.7	4.8	80.0	22.1
1984	506.5	101.0	10.4	214.0	4.5	25.0	42.4	4.2	90.0	15.0
1985	581.9	118.7	15.5	206.0	5.4	32.3	46.8	5.3	134.0	17.9
Projected										
=========										
1986	617.0	119.9	17.8	217.2	6.5	33.8	57.1	5.4	138.5	20.9
1987	643.0	121.3	20.5	214.9	7.3	35.8	62.3	5.5	152.3	23.3
1988	670.0	123.2	23.0	213.6	8.0	37.7	66.8	5.6	166.3	25.8
1989	696.0	125.2	25.3	212.8	8.6	39.5	70.3	5.7	180.2	28.4
1990	723.0	127.9	27.2	213.3	9.2	41.3	73.0	5.9	194.1	31.1
1991	750.0	131.0	28.8	214.6	9.7	43.1	75.2	6.1	207.8	33.7
1992	776.0	134.2	30.0	216.5	10.1	45.0	76.7	6.2	220.9	36.3
1993	803.0	138.0	31.1	219.6	10.4	46.6	78.2	6.5	233.8	38.9
1994	829.0	142.1	31.9	223.0	10.8	48.2	79.3	6.6	245.8	41.3
1995	856.0	146.6	32.5	227.5	11.0	49.9	80.4	6.9	257.4	43.8
1996	883.0	151.5	33.2	232.5	11.2	51.5	81.5	7.1	268.5	46.0
1997	909.0	156.4	33.7	237.8	11.5	53.0	82.5	7.4	278.7	48.1
1998	936.0	161.7	34.3	243.9	11.7	54.5	83.6	7.6	288.5	50.1
1999	962.0	167.1	34.8	250.2	11.9	56.0	84.6	7.9	297.7	51.9
2000	989.0	172.8	35.4	257.1	12.0	57.5	85.8	8.2	306.5	53.7
2001	1016.0	178.5	35.9	264.4	12.3	58.9	87.1	8.5	315.0	55.4
2002	1042.0	184.3	36.4	271.8	12.4	60.3	88.4	8.7	322.8	56.9
2003	1069.0	190.3	37.0	279.7	12.6	61.7	89.6	9.0	330.7	58.5
2004	1095.0	196.2	37.5	287.7	12.9	63.0	91.0	9.2	337.8	59.8
2005	1122.0	202.3	38.1	296.0	13.1	64.3	92.3	9.5	345.2	61.2
2006	1149.0	208.3	38.8	304.6	13.3	65.6	93.8	9.8	352.3	62.5
2007	1175.0	214.3	39.3	313.2	13.5	66.9	95.2	10.0	358.9	63.8
2008	1202.0	220.7	39.9	322.1	13.7	68.1	96.7	10.3	365.6	65.0
2009	1228.0	226.1	40.5	331.1	13.9	69.3	98.1	10.6	372.1	66.2
2010	1255.0	232.1	41.2	340.3	14.1	70.6	99.6	10.8	378.8	67.5

Table AII-6-3 PROVINCE-WISE MAIZE CULTIVATION AREA IN % OF OF TOTAL ZAMBIAN CULTIVATED AREA

(Unit: %)

	Total (A)	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
1982	100.0	22.2	1.6	43.1	0.6	5.0	5.4	0.9	18.7	2.4
1983	100.0	26.9	1.4	40.4	0.6	4.6	6.5	0.9	14.6	4.0
1984	100.0	19.9	2.1	42.3	0.9	4.9	8.4	0.8	17.8	3.0
1985	100.0	20.4	2.7	35.4	0.9	5.6	8.0	0.9	23.0	3.1
Projected										
1986	100.0	20.6	2.7	37.1	0.9	5.1	8.8	0.8	20.7	3.1
1987	100.0	20.1	3.0	36.1	1.1	5.1	9.3	0.7	21.5	3.1
1988	100.0	19.5	3.2	35.1	1.1	5.1	9.8	0.7	22.2	3.1
1989	100.0	19.0	3.5	34.1	1.2	5.2	10.4	0.7	22.9	3.1
1990	100.0	18.5	3.7	33.2	1.2	5.2	10.9	0.7	23.5	3.1
1991	100.0	18.0	3.9	32.4	1.3	5.2	11.3	0.6	24.1	3.1
1992	100.0	17.6	4.1	31.6	1.3	5.3	11.7	0.6	24.7	3.1
1993	100.0	17.2	4.2	30.9	1.4	5.3	12.1	0.6	25.2	3.1
1994	100.0	16.8	4.4	30.1	1.4	5.3	12.5	0.6	25.7	3.1
1995	100.0	16.4	4.6	29.4	1.5	5.3	12.9	0.6	26.2	3.1
1996	100.0	16.0	4.7	28.8	1.5	5.4	13.2	0.6	26.6	3.1
1997	100.0	15.7	4.8	28.3	1.6	5.3	13.5	0.5	27.0	3.2
1998	100.0	15.4	5.0	27.7	1.6	5.4	13.8	0.5	27.4	3.2
1999	100.0	15.1	5.1	27.1	1.7	5.4	14.1	0.5	27.8	3.2
2000	100.0	14.8	5.3	26.6	1.7	5.4	14.3	0.5	28.1	3.2
2001	100.0	14.5	5.4	26.1	1.8	5.4	14.6	0.5	28.5	3.2
2002	100.0	14.3	5.5	25.7	1.8	5.4	14.8	0.4	28.8	3.2
2003	100.0	13.9	5.5	25.0	1.8	5.4	15.0	0.4	29.0	3.2
2004	100.0	13.8	5.7	24.8	1.8	5.5	15.3	0.4	29.4	3.2
2005	100.0	13.6	5.8	24.4	1.8	5.5	15.6	0.4	29.7	3.2
2006	100.0	13.4	5.9	24.0	1.8	5.5	15.7	0.4	30.0	3.2
2007	100.0	13.2	6.0	23.7	1.9	5.5	16.0	0.4	30.3	3.2
2008	100.0	12.9	6.1	23.3	1.9	5.5	16.2	0.4	30.6	3.2
2009	100.0	12.8	6.2	22.9	1.9	5.5	16.3	0.3	30.8	3.2
2010	100.0	12.6	6.2	22.6	2.0	5.5	16.5	0.3	31.0	3.2

Table AII-6-4 POTENTIAL AND ACTUAL DEMAND FOR FERTILIZER IN ZAMBIA, 1982-1985

(Unit: 1,000 ton)

			Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
	Cultivated Area (1,000 ha)	1982	454.5	101.0	7.4	196.0	2.9	22.7	24.5	4.2	85.0	10.8
		1983	546.7	147.0	7.7	221.0	3.4	25.0	35.7	4.8	80.0	22.1
		1984	506.5	101.0	10.4	214.0	4.5	25.0	42.4	4.2	90.0	15.0
		1985	581.9	118.7	15.5	206.0	5.4	32.3	46.8	5.3	134.0	17.9
N-Fert.	Actural Cons. (A)	1982	54.4	14.27	1.66	8.44	0.26	8.30	4.54	0.53	16.18	0.22
		1983	43.6	9.52	1.25	11.51	0.44	4.48	4.59	0.56	10.77	0.51
		1984	38.1	9.60	1.84	6.49	0.48	2.36	4.87	0.24	11.67	0.60
		1985	55.7	14.83	2.71	15.18	0.96	3.85	3.33	0.53	13.30	1.03
	Potential Demand (B)	1982	50.9	11.31	0.83	21.95	0.32	2.54	2.74	0.47	9.52	1.21
		1983	61.2	16.46	0.86	24.75	0.38	2.80	4.00	0.54	8.96	2.48
		1984	56.7	11.31	1.16	23.97	0.50	2.80	4.75	0.47	10.08	1.68
		1985	65.2	13.29	1.74	23.07	0.60	3.62	5.24	0.59	15.01	2.00
	Ratio (%) (A/B)	1982	106.9	126.2	200.0	38.5	81.3	326.8	165.7	112.8	170.0	18.2
		1983	71.2	57.8	145.3	46.5	115.8	160.0	114.8	103.7	120.2	20.6
		1984	67.2	84.9	158.6	27.1	96.0	84.3	102.5	51.1	115.8	35.7
		1985	85.4	111.6	155.7	65.8	160.0	106.4	63.5	89.8	88.6	51.5
		Ave.		95.1	164.9	44.5	113.3	169.4	111.6	89.4	123.7	31.5
		M.D.		31.7	23.4	15.6	32.8	105.0	38.2	25.5	30.9	16.1
P-Fert.	Actual Cons. (A)	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
	Potential Demand (B)	1982	18.2	4.04	0.30	7.84	0.12	0.91	0.98	0.17	3.40	0.43
		1983	21.9	5.88	0.31	8.84	0.14	1.00	1.43	0.19	3.20	0.88
		1984	20.3	4.04	0.42	8.56	0.18	1.00	1.70	0.17	3.60	0.60
		1985	23.3	4.75	0.62	8.24	0.22	1.29	1.87	0.21	5.36	0.72
	Ratio (%) (A/B)	1982	119.2	104.0	243.3	44.1	141.7	361.5	246.9	111.8	211.2	18.6
		1983	72.1	58.5	167.7	40.5	235.7	169.0	107.7	68.4	134.7	18.2
		1984	60.6	74.8	166.7	14.4	161.1	137.0	85.3	17.6	113.1	23.3
		1985	84.1	90.3	156.5	60.1	145.5	126.4	75.9	104.8	102.1	54.2
		Ave.		81.9	183.6	39.8	171.0	198.5	129.0	75.7	140.3	28.6
		M.D.		20.3	39.8	16.9	43.1	108.7	78.6	43.5	47.3	17.1
K-Fert.	Actural Cons. (A)	1982	8.0	2.22	0.34	1.71	0.09	1.62	1.21	0.10	0.70	0.03
		1983	6.3	1.77	0.29	1.82	0.16	0.95	0.77	0.06	0.35	0.08
		1984	4.6	1.59	0.36	0.64	0.15	0.78	0.72	0.02	0.27	0.07
		1985	7.9	2.20	0.51	2.55	0.16	0.87	0.71	0.11	0.58	0.19
	Potential Demand (B)	1982	9.1	2.02	0.15	3.92	0.06	0.45	0.49	0.08	1.70	0.22
		1983	10.9	2.94	0.15	4.42	0.07	0.50	0.71	0.10	1.60	0.44
		1984	10.1	2.02	0.21	4.28	0.09	0.50	0.85	0.08	1.80	0.30
		1985	11.6	2.37	0.31	4.12	0.11	0.65	0.94	0.11	2.68	0.36
	Ratio (%) (A/B)	1982	87.9	109.9	226.7	43.6	150.0	360.0	246.9	125.0	41.2	13.6
		1983	57.8	60.2	193.3	41.2	228.6	190.0	108.5	60.0	21.9	18.2
		1984	45.5	78.7	171.4	15.0	166.7	156.0	84.7	25.0	15.0	23.3
		1985	68.1	92.8	164.5	61.9	145.5	133.8	75.5	100.0	21.6	52.8
		Ave.		85.4	189.0	40.4	172.7	210.0	128.9	77.5	24.9	27.0
		M.D.		21.3	28.0	17.0	37.3	100.0	78.7	46.7	10.9	17.2

Table AII-6-5 (1) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(NITROGEN FERTILIZER/MEAN CASE)

(Unit: '000 N ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
======										
1982	54.4	14.27	1.66	8.44	0.26	8.30	4.54	0.53	16.18	0.22
1983	43.6	9.52	1.25	11.51	0.44	4.48	4.59	0.56	10.77	0.51
1984	38.1	9.60	1.84	6.49	0.48	2.36	4.87	0.24	11.67	0.60
1985	55.7	14.83	2.71	15.18	0.96	3.85	3.33	0.53	13.30	1.03
Projected										
=========										
1986	61.6	12.8	3.3	10.8	0.8	6.4	7.1	0.5	19.2	0.7
1987	65.4	12.9	3.8	10.7	0.9	6.8	7.8	0.6	21.1	0.8
1988	68.9	13.1	4.2	10.6	1.0	7.2	8.3	0.6	23.0	0.9
1989	72.6	13.3	4.7	10.6	1.1	7.5	8.8	0.6	25.0	1.0
1990	75.9	13.6	5.0	10.6	1.2	7.8	9.1	0.6	26.9	1.1
1991	79.4	14.0	5.3	10.7	1.2	8.2	9.4	0.6	28.8	1.2
1992	82.5	14.3	5.5	10.8	1.3	8.5	9.6	0.6	30.6	1.3
1993	85.7	14.7	5.7	10.9	1.3	8.8	9.8	0.7	32.4	1.4
1994	88.8	15.1	5.9	11.1	1.4	9.1	9.9	0.7	34.1	1.5
1995	91.7	15.6	6.0	11.3	1.4	9.5	10.0	0.7	35.7	1.5
1996	94.7	16.1	6.1	11.6	1.4	9.8	10.2	0.7	37.2	1.6
1997	97.7	16.7	6.2	11.9	1.5	10.1	10.3	0.7	38.6	1.7
1998	100.5	17.2	6.3	12.2	1.5	10.3	10.4	0.8	40.0	1.8
1999	103.2	17.8	6.4	12.5	1.5	10.6	10.6	0.8	41.2	1.8
2000	106.0	18.4	6.5	12.8	1.5	10.9	10.7	0.8	42.5	1.9
2001	109.0	19.0	6.6	13.2	1.6	11.2	10.9	0.9	43.6	2.0
2002	111.4	19.6	6.7	13.5	1.6	11.4	11.0	0.9	44.7	2.0
2003	114.3	20.3	6.8	13.9	1.6	11.7	11.2	0.9	45.8	2.1
2004	116.9	20.9	6.9	14.3	1.6	12.0	11.4	0.9	46.8	2.1
2005	119.7	21.5	7.0	14.8	1.7	12.2	11.5	1.0	47.8	2.2
2006	122.4	22.2	7.2	15.2	1.7	12.4	11.7	1.0	48.8	2.2
2007	125.0	22.8	7.3	15.6	1.7	12.7	11.9	1.0	49.7	2.3
2008	127.7	23.5	7.4	16.1	1.7	12.9	12.1	1.0	50.7	2.3
2009	130.3	24.1	7.5	16.5	1.8	13.1	12.3	1.1	51.6	2.3
2010	132.9	24.7	7.6	17.0	1.8	13.4	12.4	1.1	52.5	2.4

Table AII-6-5 (2) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(NITROGEN FERTILIZER/HIGH CASE)

(Unit: '000 N ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
1982	54.4	14.27	1.66	8.44	0.26	8.30	4.54	0.53	16.18	0.22
1983	43.6	9.52	1.25	11.51	0.44	4.48	4.59	0.56	10.77	0.51
1984	38.1	9.60	1.84	6.49	0.48	2.36	4.87	0.24	11.67	0.60
1985	55.7	14.83	2.71	15.18	0.96	3.85	3.33	0.53	13.30	1.03
Projected										
1986	82.3	17.0	3.8	14.6	1.1	10.4	9.6	0.7	24.0	1.1
1987	87.0	17.2	4.3	14.5	1.2	11.0	10.5	0.7	26.4	1.2
1988	91.8	17.5	4.9	14.4	1.3	11.6	11.2	0.7	28.8	1.4
1989	96.1	17.8	5.3	14.3	1.4	12.1	11.8	0.7	31.2	1.5
1990	100.8	18.2	5.7	14.4	1.5	12.7	12.2	0.8	33.6	1.7
1991	105.1	18.6	6.1	14.4	1.6	13.2	12.6	0.8	36.0	1.8
1992	109.3	19.1	6.3	14.6	1.7	13.8	12.9	0.8	38.2	1.9
1993	113.5	19.6	6.6	14.8	1.7	14.3	13.1	0.8	40.5	2.1
1994	117.4	20.2	6.7	15.0	1.8	14.8	13.3	0.8	42.6	2.2
1995	121.4	20.8	6.9	15.3	1.8	15.3	13.5	0.9	44.6	2.3
1996	125.4	21.5	7.0	15.7	1.8	15.8	13.7	0.9	46.5	2.5
1997	129.2	22.2	7.1	16.0	1.9	16.3	13.8	1.0	48.3	2.6
1998	132.9	23.0	7.2	16.4	1.9	16.7	14.0	1.0	50.0	2.7
1999	136.4	23.7	7.3	16.8	1.9	17.2	14.2	1.0	51.5	2.8
2000	140.5	24.5	7.5	17.3	2.0	17.7	14.4	1.1	53.1	2.9
2001	144.0	25.3	7.6	17.8	2.0	18.1	14.6	1.1	54.5	3.0
2002	147.5	26.2	7.7	18.3	2.0	18.5	14.8	1.1	55.9	3.0
2003	151.3	27.0	7.8	18.8	2.1	19.0	15.0	1.2	57.3	3.1
2004	154.9	27.9	7.9	19.4	2.1	19.4	15.3	1.2	58.5	3.2
2005	158.3	28.7	8.0	19.9	2.1	19.8	15.5	1.2	59.8	3.3
2006	162.0	29.6	8.2	20.5	2.2	20.2	15.7	1.3	61.0	3.3
2007	165.4	30.4	8.3	21.1	2.2	20.6	16.0	1.3	62.1	3.4
2008	168.8	31.3	8.4	21.7	2.2	20.9	16.2	1.3	63.3	3.5
2009	172.3	32.1	8.5	22.3	2.3	21.3	16.5	1.4	64.4	3.5
2010	175.9	33.0	8.7	22.9	2.3	21.7	16.7	1.4	65.6	3.6

Table AII-6-5 (3) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(NITROGEN FERTILIZER/LOW CASE)

(Unit: '000 N ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
======										
1982	54.4	14.27	1.66	8.44	0.26	8.30	4.54	0.53	16.18	0.22
1983	43.6	9.52	1.25	11.51	0.44	4.48	4.59	0.56	10.77	0.51
1984	38.1	9.60	1.84	6.49	0.48	2.36	4.87	0.24	11.67	0.60
1985	55.7	14.83	2.71	15.18	0.96	3.85	3.33	0.53	13.30	1.03
Projected										
=========										
1986	41.2	8.5	2.8	7.0	0.6	2.4	4.7	0.4	14.4	0.4
1987	43.8	8.6	3.2	7.0	0.7	2.6	5.1	0.4	15.8	0.4
1988	46.2	8.7	3.6	6.9	0.7	2.7	5.5	0.4	17.3	0.4
1989	48.8	8.9	4.0	6.9	0.8	2.8	5.8	0.4	18.7	0.5
1990	51.2	9.1	4.3	6.9	0.8	3.0	6.0	0.4	20.2	0.5
1991	53.6	9.3	4.6	6.9	0.9	3.1	6.2	0.4	21.6	0.6
1992	55.7	9.5	4.8	7.0	0.9	3.2	6.3	0.4	23.0	0.6
1993	58.0	9.8	4.9	7.1	0.9	3.4	6.4	0.5	24.3	0.7
1994	60.1	10.1	5.1	7.2	1.0	3.5	6.5	0.5	25.5	0.7
1995	62.3	10.4	5.2	7.4	1.0	3.6	6.6	0.5	26.8	0.8
1996	64.2	10.8	5.3	7.5	1.0	3.7	6.7	0.5	27.9	0.8
1997	66.0	11.1	5.3	7.7	1.0	3.8	6.8	0.5	29.0	0.8
1998	68.1	11.5	5.4	7.9	1.1	3.9	6.9	0.5	30.0	0.9
1999	70.0	11.9	5.5	8.1	1.1	4.0	7.0	0.6	30.9	0.9
2000	71.9	12.3	5.6	8.3	1.1	4.1	7.1	0.6	31.9	0.9
2001	73.8	12.7	5.7	8.6	1.1	4.2	7.2	0.6	32.7	1.0
2002	75.6	13.1	5.8	8.8	1.1	4.3	7.3	0.6	33.6	1.0
2003	77.5	13.5	5.9	9.1	1.1	4.5	7.4	0.6	34.4	1.0
2004	79.1	13.9	5.9	9.3	1.2	4.5	7.5	0.7	35.1	1.0
2005	81.1	14.4	6.0	9.6	1.2	4.6	7.6	0.7	35.9	1.1
2006	82.8	14.8	6.1	9.9	1.2	4.7	7.7	0.7	36.6	1.1
2007	84.4	15.2	6.2	10.1	1.2	4.8	7.8	0.7	37.3	1.1
2008	86.2	15.7	6.3	10.4	1.2	4.9	7.9	0.7	38.0	1.1
2009	88.2	16.1	6.4	10.7	1.3	5.0	8.1	0.8	38.7	1.1
2010	90.0	16.5	6.5	11.0	1.3	5.1	8.2	0.8	39.4	1.2

Table AII-6-5 (4) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(PHOSPHATE FERTILIZER/MEAN CASE)

(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 AII-6-5 (5) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(PHOSPHATE FERTILIZER/HIGH CASE)

(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	32.0	4.9	1.6	4.9	0.6	4.2	4.7	0.3	10.4	0.4
1987	34.0	5.0	1.8	4.9	0.6	4.4	5.2	0.3	11.4	0.4
1988	36.0	5.0	2.1	4.8	0.7	4.6	5.5	0.3	12.5	0.5
1989	37.9	5.1	2.3	4.8	0.7	4.9	5.8	0.3	13.5	0.5
1990	39.9	5.2	2.4	4.8	0.8	5.1	6.1	0.3	14.6	0.6
1991	41.7	5.4	2.6	4.9	0.8	5.3	6.2	0.3	15.6	0.6
1992	43.5	5.5	2.7	4.9	0.9	5.5	6.4	0.3	16.6	0.7
1993	45.0	5.6	2.8	5.0	0.9	5.7	6.5	0.3	17.5	0.7
1994	46.7	5.8	2.9	5.1	0.9	5.9	6.6	0.3	18.4	0.8
1995	48.2	6.0	2.9	5.2	0.9	6.1	6.7	0.3	19.3	0.8
1996	49.8	6.2	3.0	5.3	1.0	6.3	6.8	0.3	20.1	0.8
1997	51.4	6.4	3.0	5.4	1.0	6.5	6.9	0.4	20.9	0.9
1998	52.7	6.6	3.1	5.5	1.0	6.7	6.9	0.4	21.6	0.9
1999	54.1	6.8	3.1	5.7	1.0	6.9	7.0	0.4	22.3	0.9
2000	55.7	7.1	3.2	5.8	1.0	7.1	7.1	0.4	23.0	1.0
2001	57.0	7.3	3.2	6.0	1.1	7.2	7.2	0.4	23.6	1.0
2002	58.4	7.5	3.3	6.2	1.1	7.4	7.3	0.4	24.2	1.0
2003	59.8	7.8	3.3	6.3	1.1	7.6	7.4	0.4	24.8	1.1
2004	61.1	8.0	3.4	6.5	1.1	7.7	7.6	0.4	25.3	1.1
2005	62.6	8.3	3.4	6.7	1.1	7.9	7.7	0.5	25.9	1.1
2006	63.9	8.5	3.5	6.9	1.1	8.1	7.8	0.5	26.4	1.1
2007	65.3	8.8	3.5	7.1	1.2	8.2	7.9	0.5	26.9	1.2
2008	66.6	9.0	3.6	7.3	1.2	8.4	8.0	0.5	27.4	1.2
2009	67.7	9.2	3.6	7.5	1.2	8.5	8.1	0.5	27.9	1.2
2010	69.2	9.5	3.7	7.7	1.2	8.7	8.3	0.5	28.4	1.2

Table AII-6-5 (6) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(PHOSPHATE FERTILIZER/LOW CASE)

(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	14.1	3.0	1.0	2.0	0.3	1.2	1.2	0.1	5.2	0.1
1987	15.1	3.0	1.2	2.0	0.4	1.3	1.3	0.1	5.7	0.1
1988	15.8	3.0	1.3	2.0	0.4	1.4	1.3	0.1	6.2	0.1
1989	16.6	3.1	1.5	1.9	0.4	1.4	1.4	0.1	6.7	0.1
1990	17.7	3.2	1.6	2.0	0.5	1.5	1.5	0.1	7.2	0.1
1991	18.4	3.2	1.7	2.0	0.5	1.5	1.5	0.1	7.7	0.2
1992	19.1	3.3	1.7	2.0	0.5	1.6	1.5	0.1	8.2	0.2
1993	20.0	3.4	1.8	2.0	0.5	1.7	1.6	0.1	8.7	0.2
1994	20.6	3.5	1.8	2.0	0.6	1.7	1.6	0.1	9.1	0.2
1995	21.5	3.6	1.9	2.1	0.6	1.8	1.6	0.1	9.6	0.2
1996	22.0	3.7	1.9	2.1	0.6	1.8	1.6	0.1	10.0	0.2
1997	22.9	3.9	1.9	2.2	0.6	1.9	1.7	0.1	10.4	0.2
1998	23.5	4.0	2.0	2.2	0.6	2.0	1.7	0.1	10.7	0.2
1999	24.1	4.1	2.0	2.3	0.6	2.0	1.7	0.1	11.1	0.2
2000	24.8	4.3	2.0	2.4	0.6	2.1	1.7	0.1	11.4	0.2
2001	25.5	4.4	2.1	2.4	0.6	2.1	1.8	0.1	11.7	0.3
2002	26.1	4.5	2.1	2.5	0.6	2.2	1.8	0.1	12.0	0.3
2003	26.7	4.7	2.1	2.6	0.6	2.2	1.8	0.1	12.3	0.3
2004	27.4	4.8	2.2	2.6	0.7	2.3	1.8	0.1	12.6	0.3
2005	28.0	5.0	2.2	2.7	0.7	2.3	1.9	0.1	12.8	0.3
2006	28.6	5.1	2.2	2.8	0.7	2.4	1.9	0.1	13.1	0.3
2007	29.3	5.3	2.3	2.9	0.7	2.4	1.9	0.1	13.4	0.3
2008	29.7	5.4	2.3	3.0	0.7	2.4	1.9	0.1	13.6	0.3
2009	30.3	5.6	2.3	3.0	0.7	2.5	2.0	0.1	13.8	0.3
2010	30.9	5.7	2.4	3.1	0.7	2.5	2.0	0.1	14.1	0.3

Table AII-6-5 (7) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(POTASSIUM FERTILIZER/MEAN CASE)

(Unit: '000 K20 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
======										
1982	8.0	2.22	0.34	1.71	0.09	1.62	1.21	0.10	0.70	0.03
1983	6.3	1.77	0.29	1.82	0.16	0.95	0.77	0.06	0.35	0.08
1984	4.6	1.59	0.36	0.64	0.15	0.78	0.72	0.02	0.27	0.07
1985	7.9	2.20	0.51	2.55	0.16	0.87	0.71	0.11	0.58	0.19
Projected										
=========										
1986	8.5	2.05	0.67	1.75	0.22	1.42	1.47	0.08	0.69	0.11
1987	8.9	2.07	0.77	1.74	0.25	1.50	1.61	0.09	0.76	0.13
1988	9.3	2.10	0.87	1.73	0.28	1.58	1.72	0.09	0.83	0.14
1989	9.7	2.14	0.96	1.72	0.30	1.66	1.81	0.09	0.90	0.15
1990	10.1	2.18	1.03	1.72	0.32	1.73	1.88	0.09	0.97	0.17
1991	10.5	2.24	1.09	1.73	0.34	1.81	1.94	0.09	1.03	0.18
1992	10.8	2.29	1.13	1.75	0.35	1.89	1.98	0.10	1.10	0.20
1993	11.1	2.36	1.18	1.77	0.36	1.96	2.02	0.10	1.16	0.21
1994	11.4	2.43	1.21	1.80	0.37	2.02	2.04	0.10	1.22	0.22
1995	11.8	2.50	1.23	1.84	0.38	2.10	2.07	0.11	1.28	0.24
1996	12.1	2.59	1.25	1.88	0.39	2.16	2.10	0.11	1.34	0.25
1997	12.4	2.67	1.27	1.92	0.40	2.23	2.13	0.11	1.39	0.26
1998	12.7	2.76	1.30	1.97	0.40	2.29	2.16	0.12	1.44	0.27
1999	13.0	2.85	1.32	2.02	0.41	2.35	2.18	0.12	1.48	0.28
2000	13.4	2.95	1.34	2.08	0.41	2.42	2.21	0.13	1.53	0.29
2001	13.7	3.05	1.36	2.14	0.42	2.47	2.25	0.13	1.57	0.30
2002	14.0	3.15	1.38	2.20	0.43	2.53	2.28	0.13	1.61	0.31
2003	14.4	3.25	1.40	2.26	0.44	2.59	2.31	0.14	1.65	0.32
2004	14.7	3.35	1.42	2.32	0.45	2.65	2.35	0.14	1.68	0.32
2005	15.0	3.46	1.44	2.39	0.45	2.70	2.38	0.15	1.72	0.33
2006	15.4	3.56	1.47	2.46	0.46	2.76	2.42	0.15	1.75	0.34
2007	15.7	3.66	1.49	2.53	0.47	2.81	2.45	0.16	1.79	0.34
2008	16.0	3.77	1.51	2.60	0.47	2.86	2.49	0.16	1.82	0.35
2009	16.4	3.86	1.53	2.68	0.48	2.91	2.53	0.16	1.85	0.36
2010	16.7	3.96	1.56	2.75	0.49	2.97	2.57	0.17	1.89	0.36

Table AII-6-5 (8) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(POTASSIUM FERTILIZER/HIGH CASE)

(Unit: '000 K20 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
1982	8.0	2.22	0.34	1.71	0.09	1.62	1.21	0.10	0.70	0.03
1983	6.3	1.77	0.29	1.82	0.16	0.95	0.77	0.06	0.35	0.08
1984	4.6	1.59	0.36	0.64	0.15	0.78	0.72	0.02	0.27	0.07
1985	7.9	2.20	0.51	2.55	0.16	0.87	0.71	0.11	0.58	0.19
Projected										
1986	11.9	2.56	0.77	2.49	0.27	2.10	2.37	0.13	0.99	0.18
1987	12.5	2.59	0.89	2.47	0.31	2.22	2.59	0.14	1.09	0.21
1988	13.1	2.63	1.00	2.45	0.34	2.34	2.77	0.14	1.19	0.23
1989	13.6	2.67	1.10	2.44	0.36	2.45	2.92	0.14	1.29	0.25
1990	14.2	2.73	1.18	2.45	0.39	2.56	3.03	0.15	1.39	0.27
1991	14.7	2.80	1.25	2.46	0.41	2.67	3.12	0.15	1.49	0.30
1992	15.1	2.86	1.30	2.49	0.42	2.79	3.18	0.15	1.58	0.32
1993	15.6	2.94	1.35	2.52	0.44	2.89	3.25	0.16	1.67	0.34
1994	16.0	3.03	1.38	2.56	0.45	2.99	3.29	0.16	1.76	0.37
1995	16.4	3.13	1.41	2.61	0.46	3.09	3.34	0.17	1.84	0.39
1996	16.9	3.23	1.44	2.67	0.47	3.19	3.38	0.18	1.92	0.41
1997	17.3	3.34	1.46	2.73	0.48	3.29	3.43	0.18	2.00	0.43
1998	17.8	3.45	1.49	2.80	0.49	3.38	3.47	0.19	2.07	0.44
1999	18.2	3.57	1.51	2.87	0.50	3.47	3.51	0.20	2.13	0.46
2000	18.7	3.69	1.54	2.95	0.50	3.57	3.56	0.20	2.19	0.47
2001	19.2	3.81	1.56	3.04	0.52	3.65	3.62	0.21	2.26	0.49
2002	19.6	3.93	1.58	3.12	0.52	3.74	3.67	0.22	2.31	0.50
2003	20.1	4.06	1.61	3.21	0.53	3.83	3.72	0.22	2.37	0.52
2004	20.5	4.19	1.63	3.30	0.54	3.91	3.78	0.23	2.42	0.53
2005	21.0	4.32	1.65	3.40	0.55	3.99	3.83	0.24	2.47	0.54
2006	21.5	4.45	1.68	3.50	0.56	4.07	3.89	0.24	2.52	0.55
2007	21.9	4.57	1.71	3.60	0.57	4.15	3.95	0.25	2.57	0.56
2008	22.4	4.71	1.73	3.70	0.58	4.22	4.01	0.26	2.62	0.57
2009	22.8	4.82	1.76	3.80	0.58	4.30	4.07	0.26	2.66	0.59
2010	23.3	4.95	1.79	3.91	0.59	4.38	4.14	0.27	2.71	0.60

Table AII-6-5 (9) PROJECTED DEMAND FOR FERTILIZER, 1986-2010
(POTASSIUM FERTILIZER/LOW CASE)

(Unit: '000 K20 ton)

	Total	Central	Copper-belt	Eastern	Luapula	Lusaka	North-ern	North-western	South-ern	Western
Actual										
======										
1982	8.0	2.22	0.34	1.71	0.09	1.62	1.21	0.10	0.70	0.03
1983	6.3	1.77	0.29	1.82	0.16	0.95	0.77	0.06	0.35	0.08
1984	4.6	1.59	0.36	0.64	0.15	0.78	0.72	0.02	0.27	0.07
1985	7.9	2.20	0.51	2.55	0.16	0.87	0.71	0.11	0.58	0.19
Projected										
=========										
1986	5.1	1.54	0.57	1.02	0.18	0.74	0.57	0.03	0.39	0.04
1987	5.4	1.56	0.66	1.01	0.20	0.79	0.63	0.03	0.43	0.05
1988	5.6	1.58	0.74	1.00	0.22	0.83	0.67	0.03	0.47	0.05
1989	5.8	1.61	0.81	1.00	0.23	0.87	0.71	0.04	0.50	0.06
1990	6.1	1.64	0.88	1.00	0.25	0.91	0.73	0.04	0.54	0.06
1991	6.3	1.68	0.93	1.00	0.26	0.95	0.76	0.04	0.58	0.07
1992	6.5	1.72	0.97	1.01	0.27	0.99	0.77	0.04	0.62	0.07
1993	6.7	1.77	1.00	1.03	0.28	1.03	0.79	0.04	0.65	0.08
1994	6.9	1.82	1.03	1.04	0.29	1.06	0.80	0.04	0.69	0.08
1995	7.1	1.88	1.05	1.06	0.30	1.10	0.81	0.04	0.72	0.09
1996	7.2	1.94	1.07	1.09	0.30	1.13	0.82	0.04	0.75	0.09
1997	7.4	2.01	1.09	1.11	0.31	1.17	0.83	0.05	0.78	0.09
1998	7.6	2.07	1.10	1.14	0.32	1.20	0.84	0.05	0.81	0.10
1999	7.8	2.14	1.12	1.17	0.32	1.23	0.85	0.05	0.83	0.10
2000	8.0	2.22	1.14	1.20	0.32	1.27	0.86	0.05	0.86	0.11
2001	8.2	2.29	1.16	1.24	0.33	1.30	0.87	0.05	0.88	0.11
2002	8.4	2.36	1.17	1.27	0.34	1.33	0.89	0.05	0.90	0.11
2003	8.6	2.44	1.19	1.31	0.34	1.36	0.90	0.06	0.93	0.11
2004	8.9	2.52	1.21	1.35	0.35	1.39	0.91	0.06	0.95	0.12
2005	9.1	2.59	1.23	1.39	0.35	1.41	0.93	0.06	0.97	0.12
2006	9.3	2.67	1.25	1.43	0.36	1.44	0.94	0.06	0.99	0.12
2007	9.5	2.75	1.27	1.47	0.37	1.47	0.96	0.06	1.00	0.13
2008	9.7	2.83	1.28	1.51	0.37	1.50	0.97	0.06	1.02	0.13
2009	9.9	2.90	1.30	1.55	0.38	1.52	0.98	0.07	1.04	0.13
2010	10.1	2.98	1.33	1.59	0.38	1.55	1.00	0.07	1.06	0.13

FEATURES OF PHOSPHATE RESERVES AT CHILEMBWE, ZAMBIA AND CONSIDERATIONS FOR USE AS RAW MATERIALS FOR PHOSPHATE FERTILIZER PRODUCTION

1. Introduction

The present feasibility study has been undertaken for the efficient utilization of phosphate concentrate of Chilembwe, which will be mined and concentrated using phosphate reserves at Chilembwe, Zambia, for the domestic production of fused magnesium phosphate or single super phosphate fertilizers in Zambia.

The details of Chilembwe's phosphate reserves and development plan are presented in "A Pre-Feasibility Study for the Phosphate Development Project, the Republic of Zambia, 1985, Japan International Cooperation Agency" and the details of experimental results on the phosphate concentrate, fused magnesium phosphate and single super phosphate production, and the conceptual design of the projects are summarized in the Part III of the Report.

A further supplementary explanation on the specific features of the Chilembwe's phosphate reserves are given hereunder as Annex of the Report.

2. Scale of Phosphate Reserve

World production of phosphate rock (concentrate) amounted to 150.1 MM TPY (equivalent to 45.03 MM TPY-P_2O_5) in 1985, 0.3 MM TPY more than in 1984 and the historical highest level even recorded. The world export of phosphate amounted to 46.5 MM TPY, in 1985, 1.25 MM TPY less than in 1984.

Major production, exporting and importing countries of phosphate in 1985 are cited as follows:

Major Production, Export and Import Countries of Phosphate Concentrate-1985

Production, MM TPY		Export, MM TPY		Import, MM TPY	
USA	50.84	Morocco/Sahara	14.79	France	4.15
USSR	30.50	USA	10.76	Poland	3.26
Morocco/Sahara	20.74	Jordan	4.61	Spain	2.81
China PR	12.00	USSR	3.95	Romania	2.78
Jordan	6.07	Nauru/Christmas	2.61	Belgium	2.61
Tunisia	4.53	Togo	2.45	Canada	2.59
Brazil	4.21	Israel	2.30	Japan	2.44
Israel	4.08	Senegal	1.25	Netherland	2.09
Togo	2.45	Tunisia	1.13	Germany FR	2.09
South Africa	2.42	Syria	0.89	South Korea	1.87
...	...	...	...	...	...
Total:	150.07	Total:	46.53	Total:	46.53

Source: Phosphate and Potassium, No.144, 1986, The British Sulfur Corp., Ltd.

The scale of individual mining operation is averaged 3.0 MM TPY in the world, and its mining cost for newly implementing projects are estimated US$30.5 to 38.5/Ton in developed site and US$53.9 to 62.4/Ton in remote developing site in terms of constant price as of 1982 according to the study by the World Bank in 1983.

While the scale of reserves in Chilembwe is rather limited (total minable ore: 1.53 MM Ton of 11.9% P_2O_5 quality) and only enable to supply 0.035 MM TPY of phosphate concentrate with 30.0% P_2O_5 quality for 14 + years of project life. The projected production in Zambia is a marginal of 0.023% of the world production or 0.075% of word trade of phosphate concentrate. Therefore, the economy of scale is not expected, but the advantage is hoped to produce at lower cost than imported one. However, the full production cost is, as discussed in the Part IV of the Report, projected up to above US$150/Ton at Chilembwe according to the financing conditions of the project.

3. Quality of Phosphate Reserve

The phosphate ore in Chilembwe is igneous and its quality of P_2O_5 concentration ranges between 9.5 to 15.1% and averages 11.9% of P_2O_5. The phosphate is crystalline of fluorapatite and hydroxyapatite with low organic material and carbonate content. The quality of ore in P_2O_5 is rather high as ingneous phosphate and concentration efficiency by flotation is high, because of isolated and large sized crystalline structure of apatite in the ore. The P_2O_5 recovery is expected 88.4% for project conceptual design. The impurity of Cd, As and F is also low in concentration than the standard commercial phosphate.

However, the economy of scale is not contributable to reduce the production cost at Chilembwe because of the limited phosphate reserves so far confirmed in the region and the small scale flotation processing makes the production cost at higher level.

It might be also noted that the quality of P_2O_5 in sedimentary phosphate in North Africa and Middle East is high enough to mine and deliver phosphate without flotation processing to realize lower ex-mine costs of phosphate concentrate at multi-million tons mining operations.

4. Location of Phosphate Reserves

Phosphate reserve in Chilembwe is located approximately 540 km East from Kafue where the proposed phosphate fertilizer plant will be located as the most optimized plant site in Zambia. The region near Chilembwe is still developing stage in Zambia and transport infrastructure is not well established. Additional investment for project infrastructure for water supply, access roads and bridges construction and others are required.

Moreover, there is no railways system from Chilembwe to Kafue and only possible mode of transport is by truck transport by road which costs additionally US$73.5/Ton for the transportation of phosphate concentrate from mines in Chilembwe to the consuming plant in Kafue.

5. Cost Reduction Countermeasure of Phosphate Concentrate

From the production tests, it is concluded that the production of phosphate concentrate from Chilembwe ores as well as the production of fused magnesium phosphate and single super phosphate from the phosphate concentrate of Chilembwe ores are technically feasible. Major technical problems, although not so critical, encountered during the production tests are fineness of phosphate concentrate for the production of fused magnesium phosphate and low and slow reactivity of phosphate concentrate with sulfuric acid for the production of single super phosphate. By adjusting the plant design and production conditions, which will be specific for Chilembwe phosphate, it is possible to produce standard grade fused magnesium phosphate and single super phosphate in conventional production processes and normal operating procedures.

However, from the financial point of view, these projects are not viable in terms of returns on investment as well as cash flow during the project life under assumed financial conditions for the proposed projects.

Although the most critical factor for the low financial viability of the projects are the product prices which are low because of the present depressed phosphate fertilizer market prevalent in the world for a decade. The cost of phosphate concentrate is also influential factor, and the possibilities of reduction of the cost are assessed as follows:

(1) Switching to Imported Phosphate Concentrate

As the importing cost and domestically produced phosphate concentrate cost are in a same level, it is not possible to improve financial viability by switching to imported phosphate concentrate from own produced concentrate. The viability is still in negative side. Domestic production of phosphate concentrate is only beneficial when the cost is lower than the landed cost of imported phosphate concentrate in Zambia. The production of phosphate fertilizers using imported phosphate concentrate from North African supply sources is not beneficial under present conditions, because these countries also supply processed phosphate fertilizers under lower arrival pricing at Zambia.

(2) Reduction of Transportation Cost

The transportation cost of phosphate concentrate from Chilembwe to Kafue is estimated US$73.5/Ton which will be reduced substantially, if railways system is available. It is reported that a new railways system is now studied by the Government to construct the third railways system from Lusaka to Tete, Mozambique which will pass Katete, near Chilembwe and connect to the existing railways from Tete to Beira Port of Mozambique on Indian Ocean. Implementation of the railways system will be beneficial for the project.

(3) Scale of Phosphate Reserves

The scale of the conceptual design of the project facilities is rather limited in small scale because of the limited reserves so far con firmed in the region, however it is probable to find out additional quantity with high quality reserves in the region in future. The twice of the present studied production capacity will be absorbed by the domestic consumption of phosphate fertilizers in Zambia. The economy of scale will be beneficial for the project viability in Zambia.

(4) Quality of Phosphate Concentrate

The conceptual design of the phosphate mining and concentrate project is to produce phosphate concentrate with quality of P_2O_5 30.0% in dry and with free moisture of 12.0% on dry basis after the flotation and filtration for direct shipping.

However, from the production tests in Japan using surface phosphate ores in Chilembwe, a higher quality product of P_2O_5 35.0% at 97.2% of P_2O_5 recovery is obtained without any difficulty. The design allowance is for the fluctuation of ore quality for deeper mining, but the reduction of such design allowance will be possible when the ore quality data is confirmed at the deeper reserves in Chilembwe.

Although the total investment cost will not be reduced, it will also be feasible to dry the phosphate concentrate in Chilembwe instead of in Kafue for variable cost saving of phosphate concentrate transportation from Chilembwe to Kafue.

The above countermeasures will be beneficial for the improvement of financial viability of the proposed projects for future considerations.

Annex III-2

CROP RESPONSE AND EVALUATION OF FUSED MAGNESIUM PHOSPHATE FERTILIZER

1. Introduction

Effectiveness and commercial value of chemical fertilizers are closely related to the specific conditions of their fertilization environment: climate, soils, crops, agricultural practice and farm management. It is common and true for all fertilizer nutrients: nitrogen, phosphate, potash and others such as sulfur and magnesium.

Present feasibility study are undertaken on the two alternative phosphate fertilizer products of fused magnesium phosphate and single super phosphate. Single super phosphate is well known, produced and consumed widely throughout the world, but fused magnesium phosphate is rather specific and limited fertilizer, and produced commercially only in five countries in the world. Therefore, a brief description on the characteristics of fused magnesium phosphate is given hereunder as an Annex of the Report.

2. Characteristics of Fused Magnesium Phosphate

2.1 Production Method

Generally, finely ground phosphate concentrate is low or nil in agronomic response to the crops, especially igneous phosphate with well developed apatite crystal is low in comparison with sedimentary and carbonate apatite phosphate. Crop response for direct application of ground phosphate is greatly influenced by the crystalline structure of phosphate.

Therefore, it is essential to decompose the apatite crystal of phosphate by chemical processes and to convert into available phosphates which will be absorbed by the root system of agricultural crops.

Following four processes are applied for the industrial production of phosphate fertilizers at present in the world:

- Decomposition by Mineral Acid
- Decomposition by Alkali
- Decomposition by Thermal Treatment with Steaming
- Fusion and Decomposition by the Addition of Third Component

Decomposition by mineral acids are the most widely practised and applied for the production of single super phosphate, triple super phosphate, diammonium phosphate and nitric phosphate fertilizers which give highly water soluble phosphates, while the rest of the processes above cited give available phosphate with low or no water soluble phosphates.

Fused magnesium phosphate was developed in 1946 by Professor Shin-ichiro Kasugai, University of Tokyo, Japan and the first commercial production tests was conducted in 1948 by using electric furnace for melting phosphate concentrate and serpentine mixture. Since then the production of fused magnesium phosphate is spread not only in Japan but also in Korea, Brazil, South Africa and China, and open-hearth furnace are also used. The present production capacity of fused magnesium phosphate in these countries are reported approximately 5.0 MM TPY of fertilizer or 1.0 MM TPY in terms of P_2O_5 in 1986 as tabulated below:

Country	Production Capacity of Fused Magnesium Phosphate
Japan	496,000 TPY
Korea	158,000
Brazil	250,000
South Africa	50,000
China	4,000,000
Total	4,954,000 TPY

Approximate unit consumptions of fused magnesium phosphate production by electric furnace and open hearth furnace processes are as follows:

Unit Consumption for Fused Magnesium Phosphate Production

Consumption	Electric Furnace Process	Open Hearth Furnace Process
Phosphate Concentrate (P_2O_5 30.0%)	0.70 TPT	0.70 TPT
Serpentine	0.38	0.38
Electrode	0.005	-
Brick	-	0.01
Electricity	910 kWh	50 kWh
Fuel Oil	0.028 TPT	0.185 TPT
Raw Water	6.25	6.25

Where low cost hydroelectricity is adequately available, electric furnace process is applied, but where electricity is generated at fuel burning power plant, open hearth furnace process is used by firing natural gas, fuel oil or low ash coke such as petroleum coke for the production of fused magnesium phosphate.

2.2 Product Features

Molecular structure of fused magnesium phosphate is glassy and amorphous state as is verified by X-ray diffraction analysis. The constituent phosphate, lime, magnesia and silicate are all not soluble in water but highly soluble in weak acidic solution.

Therefore, these components are slowly but readily available to the agricultural crops. Fused magnesium phosphate composes of 16 to 25% of P_2O_5 and with a MgO/SiO_2 molar ratio of 1.0 which gives low melting temperature melt for easy vitrification as well as high solubility of phosphate in citric acid and acidic citrate solution.

(1) Phosphate Nutrients

Phosphate in fused magnesium phosphate is not water soluble but highly soluble in weak acidic medium. Root systems of agricultural crops secretes weak organic acid medium in soils and upon contact with fused magnesium phosphate, phosphate is dissolved in the medium and assimilated by root systems of the crops as plant nutrient.

On the contrary, when the water soluble phosphate fertilizer is applied to the soils, dissolved phosphate is reacted with active ferric, ferrous and aluminum cations in the soils and forms insoluble phosphates gradually which are no more available to the crops.

Therefore, only a fraction of phosphate in water soluble phosphate fertilizer is absorbed by crops, especially in highly acidic and lateritic soils which contain high concentration of iron and aluminum, and have high fixation capability of soluble phosphate. In such soils, the response of water soluble phosphate is relatively lower, while the response of fused magnesium phosphate is relatively higher because phosphate is not readily reactive with iron and aluminum irons to form unavailable phosphates in soils.

However, it is noted that the initial phosphate response of fused magnesium phosphate is slower during a few days period than water soluble phosphate because of its low solubility in water.

(2) Neutrallizing Effects

Fused magnesium phosphate is highly alkaline in nature and contains high concentration of lime and magnesia. Therefore, fused magnesium phosphate has neutrallizing effects of acidic soils according to the application rates. Generally, liming is practiced in highly acid soil and fused magnesium phosphate is beneficial for such neutrallizing as well as phosphate application in cropping fields.

(3) Secondary Nutrients

Besides phosphate, fused magnesium phosphate contains various secondary nutrients: approximately 15.0% of MgO, 30.0% of CaO and 25.0% of SiO_2. These nutrients are soluble and active to stimulate the growth of agricultural crops.

3. Official Analytical Methods

There are a variety of phosphate fertilizer production methods and phosphate fertilizer products in the world. Therefore, several official analytical methods have been developed which are applicable to the specific phosphate fertilizer and specific fertilization environment.

For the analysis of water soluble phosphate fertilizers, W-P_2O_5 (water soluble phosphate) is used for expressing the effectiveness of phosphate fertilizer and for the determination of commercial value of phosphate fertilizers as is stipulated in the Law of Zambia.

However, there are additional effective phosphate remaining over water soluble phosphate in triple super phosphate and in diammonium phosphate. Therefore, citrate soluble phosphate plus water soluble phosphate is measured for expressing the effectiveness of general phosphate fertilizers. In the USA, Av-P_2O_5 (available phosphate) is measured by the AOAC method by extracting phosphate with neutral ammonium citrate solution, and in Japan, S-P_2O_5 (soluble phosphate) is measured by the official method with extracting phosphate by ammoniacal alkaline ammonium citrate solution.

Other official method approved for specific fertilizer is C-P_2O_5 (citric acid soluble phosphate) which extract phosphate using 2.0% solution of citric acid. This method is developed over 100 years ago in Germany to apply phosphate effectiveness assessment of Thomas phosphate, a basic slag fertilizers, which is a co-product of steel production. Extensive agronomical research activities verified that the agronomical response of basic slag is closely correlated to C-P_2O_5 under wide ranged fertilization environments in Europe. Official methods of C-P_2O_5 has been adopted in United Kingdom, Austria, Belgium, Eire, France, West Germany, Switzerland, Netherlands, the USSR, Japan and other countries. Production of basic slag fertilizer in the world reached over 7.0 MM tons in 1960 or 1.5 MM tons in terms of P_2O_5 as is documented in following table. The production in recent years has been greatly reduced due to the technical renovation in steel production as well as the beneficiation of iron ores at mines.

Some countries, F-P_2O_5 (formic acid soluble phosphate) and C-P_2O_5-pH4 (soluble phosphate in acidic ammonium citrate solution of pH4) are approved as official method for the determination of effectiveness and commercial value of water insoluble phosphate fertilizers.

The effectiveness of fused magnesium phosphate is measured primarily by C-P_2O_5 and in some cases, C-P_2O_5-pH4 or F-P_2O_5 is applied in the water insoluble phosphate fertilizers producing countries.

BASIC SLAG FERTILIZER STATISTICS

(Unit: P_2O_5, 1,000 TPY)

Country		1964/65	1969/70	1974/75	1979/80	1983/84
Austria	- Production	-	-	-	-	-
	- Imports	54.8	46.4	21.9	12.0	na
	- Consumption	54.8	46.4	16.9	12.0	8.1
	- Exports	-	-	-	-	-
Belgium-Luxembourg	- Production	345.2	368.1	372.7	268.0	na
	- Imports	18.0	15.1	24.9	na	na
	- Consumption	63.1	55.2	89.0	16.0	na
	- Exports	306.2	300.1	296.3	na	na
France	- Production	429.4	408.6	na	na	na
	- Imports	147.5	177.0	na	na	na
	- Consumption	370.3	384.6	na	224.1	na
	- Exports	63.5	52.9	na	na	na
Germany FR	- Production	444.9	313.5	244.5	162.9	64.2
	- Imports	-	-	106.9	84.7	55.6
	- Consumption	382.6	300.1	265.6	152.3	61.7
	- Exports	42.9	36.3	-	1.2	1.8
Netherlands	- Production	-	-	-	-	-
	- Imports	39.2	21.9	14.8	6.3	2.3
	- Consumption	39.2	21.9	14.2	4.6	2.3
	- Exports	-	-	-	-	-
Poland	- Production	75.8	89.5	0.3	-	-
	- Imports	-	-	-	-	-
	- Consumption	76.8	92.5	-	-	-
	- Exports	-	-	-	-	-
United Kingdom	- Production	120.6	85.2	na	30.0	na
	- Imports	10.4	9.3	na	2.7	na
	- Consumption	127.8	95.6	na	32.0	na
	- Exports	-	-	-	-	-
Others	- Production	56.6(+)	34.6	18.8(+)	1.0(+)	-(+)
World Total	- Production	1,472.5(+)	1,299.5	636.3(+)	461.9(+)	64.2(+)

Sources: FAO Fertilizer Yearbook, 1978-1984, FAO
Annual Fertilizer Review, 1970-1977, FAO

4. Effectiveness and Commercial Value of Fused Magnesium Phosphate

As is explained in preceding sections, fused magnesium phosphate features in its alkaline and water insoluble nature, and is appreciated as an excellent fertilizer for acidic and lateritic soils. In those regions, commercial value is established at higher level than straight water soluble phosphate. In Japan, the Soil Amendment Act was introduced in 1952 for encouraging the use of fused magnesium phosphate in acidic and magnesia deficit soils due to leaching of alkaline by heavy rainfall. The P_2O_5 in fused magnesium phosphate is priced 25.0% higher than that of single super phosphate in Japan, where intensive agriculture is practiced in acidic and magnesia deficit soil extensively.

The effectiveness of specific fertilizer should be examined in accordance with the specific and regional fertilization environments: climate, soils, crops, agricultural practice and farm management. Therefore, the effectiveness evaluation of fused magnesium phosphate fertilizer in Zambia should be based on the crop response testings in Zambia.

In the present feasibility study, not only Av-P_2O_5 content but also sulfur content in the single super phosphate is reflected in its commercial value calculation in view of well recognized and accepted sulfur benefits in sulfur deficit agricultural soils in Zambia.

However, as the effectiveness of C-P_2O_5, magnesia, silica and alkaline contents in fused magnesium phosphate at Zambian climate and soils have not been well tested so far, therefore, such additional benefits for the calculation of commercial value of fused magnesium phosphate have not been reflected in the present feasibility study in Zambia.

5. Importance of Crop Response Testings of Fused Magnesium Phosphate in Zambia

In principle, a high crop response of fused magnesium phosphate is expected in Zambian soils because of the specific features of the phosphate as well as the strong acidic nature of Zambian soils. However, in practice, a fair and neutral evaluation of commercial value of fused magnesium phosphate are unable due to the lack of scientic verification records in Zambia.

Therefore, it is recommendable to undertake an intensive crop response experiments in Zambia based on well designed experimental planning. The experimental project should be designed, supervised and evaluated at the central research institution to identify the effectiveness of fused magnesium phosphate at regional experimental stations throughout Zambia.

The dosage of fertilization should be formulated taking into consideration of present and future farming practices in Zambia.

Field experiments should be continued at least three years terms to verify the following issues on fused magnesium phosphate applications in Zambia:

- Absorption of applied citric acid soluble phosphate by crops
- Agronomic effects of applied soluble magnesia
- Agronomic effects of applied soluble silica and alkaline
- Overall crops yields
- Official analytical method for fused magnesium phosphate

BRIEF INFORMATION FOR THE PRODUCTION OF TRIPLE SUPER PHOSPHATE, DIAMMONIUM PHOSPHATE AND NITRIC PHOSPHATE FERTILIZER

1. Introduction

Although the present study is confined to prepare the complete feasibility study for the production of two product alternatives: fused magnesium phosphate and single super phosphate using phosphate concentrate (P_2O_5: 30.0%, 35,181 TPY-dry for 15 years of supply) which will be mined and concentrated at Chilembwe, Zambia. The scope of work for the study is also stipulating that a brief technical information should be prepared as Annex of the Report on the three additional product alternatives: triple super phosphate (TSP), diammonium phosphate (DAP) and nitric phosphate (NP) using the same phosphate concentrate from Chilembwe.

The detailed analysis for the two projects are documented in the Report and a brief process explanation and the implications of the three additional projects on the Chilembwe phosphate in Zambia are described hereunder.

The study results show that the production of fused magnesium phosphate and single super phosphate are technically feasible to produce standard quality products by conventional technology, however the projects are not financially viable in terms of capital return and cash flow, and the projects are not justifiable in terms of economic benefit for the economy of Zambia by the financial and economic analysis under assumed conditions. It is also concluded that the switching from domestic phosphate of Chilembwe to importing one from overseas will not improve the project feasibility because of low landed cost of imported phosphate fertilizer than imported phosphate concentrate in terms of fertilizer nutrients. The financial and economic internal rate of return for the two projects are negative.

There are several reasons for such negative project feasibility of the studied projects: economy of scale, quality and location of phosphate reserves, product analysis (low in analysis and citric acid soluble phosphate), high cost of raw materials, depressed international phosphate fertilizer industries, high pricing of supplementary inputs (serpentine and sulfuric acid) in Zambia.

Taking the above project evaluation results and reasons behind for granted, it might be reasonable to conclude that the three additional product alternative projects are also negative in feasibility under the assumed conditions.

The production scale of the three additional products should also be a same as far as using Chilembwe phosphate concentrate (P_2O_5: 30.0%, 35,181 TPY -dry for 15 years of supply) and the project will be located in Kafue because of the raw material and product logistics optimization. The product analysis will be higher for the three but the product pricing by nutrients basis of available phosphate for matching to the imported product price should be the same. Therefore, project sales revenues are identical. The sulfur content in single super phosphate is advantageous for Zambian agriculture, but no sulfur is contained in the additional three products. In addition to the complexity of the project, the investment cost should be higher, because phosphoric acid plant is additionally required for the production of triple super phosphate and diammonium phosphate. The returns will be more negative because of higher capital investment and a same sales revenue.

Although the production scheme of nitric phosphate will have some advantageous aspects through by-pass utilization of ammonia and nitric acid to produce nitric phosphate melt for the production of the presently producing compound fertilizers and ammonium nitrate at the existing facilities of NCZ in Kafue without any additional supplementary inputs except carbon dioxide which will be recoverable at ammonia plant of NCZ, Kafue Zambia, the financial viability will not be positive because of depressed international fertilizer industries at present as mentioned above.

2. Phosphoric Acid

Phosphoric acid is required for the production of triple super phosphate and diammonium phosphate as an intermediate in Zambia.

Phosphoric acid (H_3PO_4) is an intermediate in the manufacture of water soluble phosphate fertilizers, except single super phosphate and nitric phosphate, and is manufactured from phosphate and sulfuric acid. Process routes for making the acid can be classified as wet (acid) and thermal (electricity). The thermal processes give an acid of higher purity but not used for fertilizer production in view of production costs.

In a wet process the phosphate is digested with an acid. The reaction taking place with sulphuric acid produces gypsum and hydrogen fluoride as by-products:

$$Ca_{10}(PO_4)_6F_2 + 10H_2SO_4 + 20H_2O = 10CaSO_4 \cdot 2H_2O + 6H_3PO_4 + 2HF$$

The reaction itself is fast, but the gypsum crystals form slowly and P_2O_5 tends to be included in the lattice of gypsum.

The various commercial processes developed have basic objectives:

- Transferring the maximum amount of P_2O_5 into product acid or ensuring little P_2O_5 left in the gypsum
- Obtaining high concentration of P_2O_5 in the product acid (30 to 45% P_2O_5)
- Having by-product gypsum in a suitable form for filtration and of acceptable quality for further uses

There are several commercially proven process know-hows available for the project in Zambia, but it is essential to carry out detailed test on phosphate concentrate from Chilembwe prior to the preparation of conceptual and basic design of the plant at the potential licensors. Recovery of phos phate and filtrability of gypsum are specific for each combination of process and phosphate concentrate. As an example, the most typical process are explained hereunder:

Phosphate concentrate ground to 90% passes through 100 mesh and sulphuric acid of 60% concentration are fed at predetermined rates to the digesters provided with agitators. The ratio between the weights of phosphate concentrate and sulphuric acid (as 100% H_2SO_4) is 1.1 to 1.2 depending on the concentrate quality. Weak phosphoric acid from the filtration section is recycled to the digesters, and slurry from the first digester flows to the second one. A temperature of 90 to 100°C is maintained in the digesters. These conditions are favourable for the growth of calcium sulphate hemihydrate ($CaSO_4 \cdot 1/2H_2O$) crystals.

The hemihydrate slurry from the second digester flows to crystallizers in series where hydrated crystals are already present. Cooling is done with air to maintain a temperature of 60 to 65°C. Under these conditions the hemihydrate crystals are dissolved so that the phosphate inclusions are transferred to the acid. Sufficient time is allowed for the seed crystals to grow, and the slurry containing the dihydrate (gypsum, $CaSO_4 \cdot 2H_2O$) is sent to filtration and is partially recycled to the crystallizer to maintain optimum conditions. The filtration is done in a tilting-pan filter, and the product acid filtrate has a concentration of 30 to 32% P_2O_5. This filtrate is sent to evaporator for increasing the concentration to 45 to 54% P_2O_5. As a by-product, gypsum is separated and recovered for disposal or industrial uses according to the specific conditions of the region.

The standard world scale of the process plant at present is 500 to 1,000 TPD - P_2O_5 while assumed project scale in Zambia is approximately 30 TPD - P_2O_5 due to the limited availability of phosphate concentrate in Chilembwe.

3. Triple Super Phosphate

Triple super phosphate (TSP) is an excellent phosphate fertilizer, with high P_2O_5 content of 44 to 48% in water-soluble form which is manufactured by reacting phosphoric acid (47 to 54% P_2O_5) with phosphate concentrate:

$$Ca_{10}(PO_4)_6F_2 + 14H_3PO_4 = 10Ca(H_2PO_4)_2 + 2HF$$

When the phosphate concentrate and phosphoric acid are mixed, the resulting mass solidifies rapidly than in the case of single super phosphate. That is the main difference between the two processes. The manufacture of triple super phosphate by typical process is described below:

Phosphate, ground to 90% passes through 100 mesh, and 47 to 54% P_2O_5 phosphoric acid are metered continuously into a mixer in a weight ratio of 1 to 1.5 to 1.6. The mixer employed is cone or turbine-agitator type. The slurry produced is discharged into a belt conveyor which acts as a den and the mass hardens in a short time. The product is then cut by a disintegrator and sent to a curing pile. After a specified curing period: approximately four weeks, the product is pulverized for shipping.

The den system is provided with a fume-scrubbing to reduce atmospheric pollution of the fluorine-bearing off-gases by lime water washing.

Triple super phosphate is manufactured in granular form also by using the conventional slurry process. Merchant grade phosphoric acid (47 to 54%

P_2O_5) and phosphate concentrate are mixed in cascade reactors. The slurry from the reactor is granulated with a pug-mill type blunger or a drum-type granulator. The granules are screened to separate and recycle the oversize material and fines. The product is sent to storage or direct shipping.

The typical product grade is (0-46.3-0) and the world scale plant has capacity of 500 to 1,000 TPD by single train. The studied project in Zambia is 72.8 TPD.

4. Diammonium Phosphate

Diammonium Phosphate (DAP) is a reaction product of two moles of ammonia and a mole of phosphoric acid, and is the most important phosphate fertilizer in the world because of high analysis of fertilizer nutrients as well as the high water solubility of phosphate. The reaction is presented as follows:

$$2NH_3 + H_3PO_4 = (NH_4)_2HPO_4$$

Ammonia is reacted with merchant grade phosphoric acid (50 to 54% P_2O_5) in a pre-neutralizer operating at 115°C, where the mole ratio of ammonia to the acid is maintained at 1.4 to 1. The slurry is pumped to the ammoniator-granulator with recycled fines and ammonia is injected to increase the mole ratio to 1.8 to 2.0 to 1. The product granules from the granulator go to a con-current drier to reduce the moisture content to 1% and then are screened. The oversize and fines are recycled; the ratio of recycle to fresh feed is 2 to 5 to 1. The product from the screens is cooled and sent to storage. Ammonia losses from the pre-neutralizer and the granulator are kept to the minimum by scrubbing the vapours with phosphoric acid and returning the acid to the pre-neutralizer. The grades obtained are in the range of (18-46-0) to (16-48-0).

The world scale plant has production capacity of 500 to 1,000 TPD by single train while the proposed project in Zambia will be 72.8 TPD.

5. Nitric Phosphate

Nitric phosphate contains the fertilizer nutrients of nitrogen and phosphate and is obtained by acidulation of phosphate concentrate with nitric acid; the resulting slurry contains a mixture of nitrates and phosphates.

The acidulation reaction between phosphate concentrate and nitric acid can be expressed as follows:

$$Ca_{10}(PO_4)_6F_2 + 20HNO_3 + 4H_2O = 6H_3PO_4 + 10Ca(NO_3)_2 \cdot 4H_2O + 2HF$$

The reaction product is in the form of water-soluble phosphoric acid and calcium nitrate. However, the calcium nitrate is hygroscopic and convert phosphate into water insoluble phosphate during granulation. Various processes have been developed to eliminate the calcium nitrate as follows:

- Removal by crystallization of $Ca(NO_2)_2 \cdot 4H_2O$ followed by centrifuging or filtration

- Conversion to calcium sulphate by using ammonium sulphate, potassium sulfate or sulphuric acid

- Conversion to monocalcium phosphate by using phosphoric acid

- Conversion to calcium carbonate by using carbon dioxide

Among these processes, the most typical process by calcium nitrate removal by deep cool crystallization is explained hereunder:

Phosphate concentrate and 55 to 60% nitric acid are fed to digesters continuously with a small amount of defoamer. The mixture flows to the second digester, where dissolution is completed. The slurry is then pumped to the crystallizers, which are equipped with cooling coils cooled by brine and operated in series continuously or in batches. The temperature maintained in the crystallizers is based on the amount of calcium nitrate to be removed and the degree of water solubility of phosphate to be obtained in the product. Easily filterable crystals of uniform particle size are obtained; these are separated by filters. The liquor from the calcium nitrate filtration stage is pumped to the neutralization section, where gaseous ammonia is added. Neutralization is carried out in stages to avoid the viscous solutions that occur at intermediate pH values. Depending on the requirement of nitrogen and phosphate in the final product, ammonium nitrate produced in the calcium nitrate conversion by ammonia and carbon dioxide is added after due concentration.

The neutralized solution is then pumped to the evaporator section, where the water content is reduced to enable prilling or drum granulation. Evaporation is done under vacuum in two stages in specially designed equipment. Scrubbing units are provided to remove fluorine and ammonia in the vapors released during evaporation. After the evaporation, the solution is either prilled or granulated. The calcium nitrate by-product separated in the filter can either be used in the production of calcium ammonium nitrate (CAN) or converted to ammonium nitrate both of which are sold as straight nitrogen fertilizers. The most typical products are (20-27-0), (22-22-0) and (27-13-0).

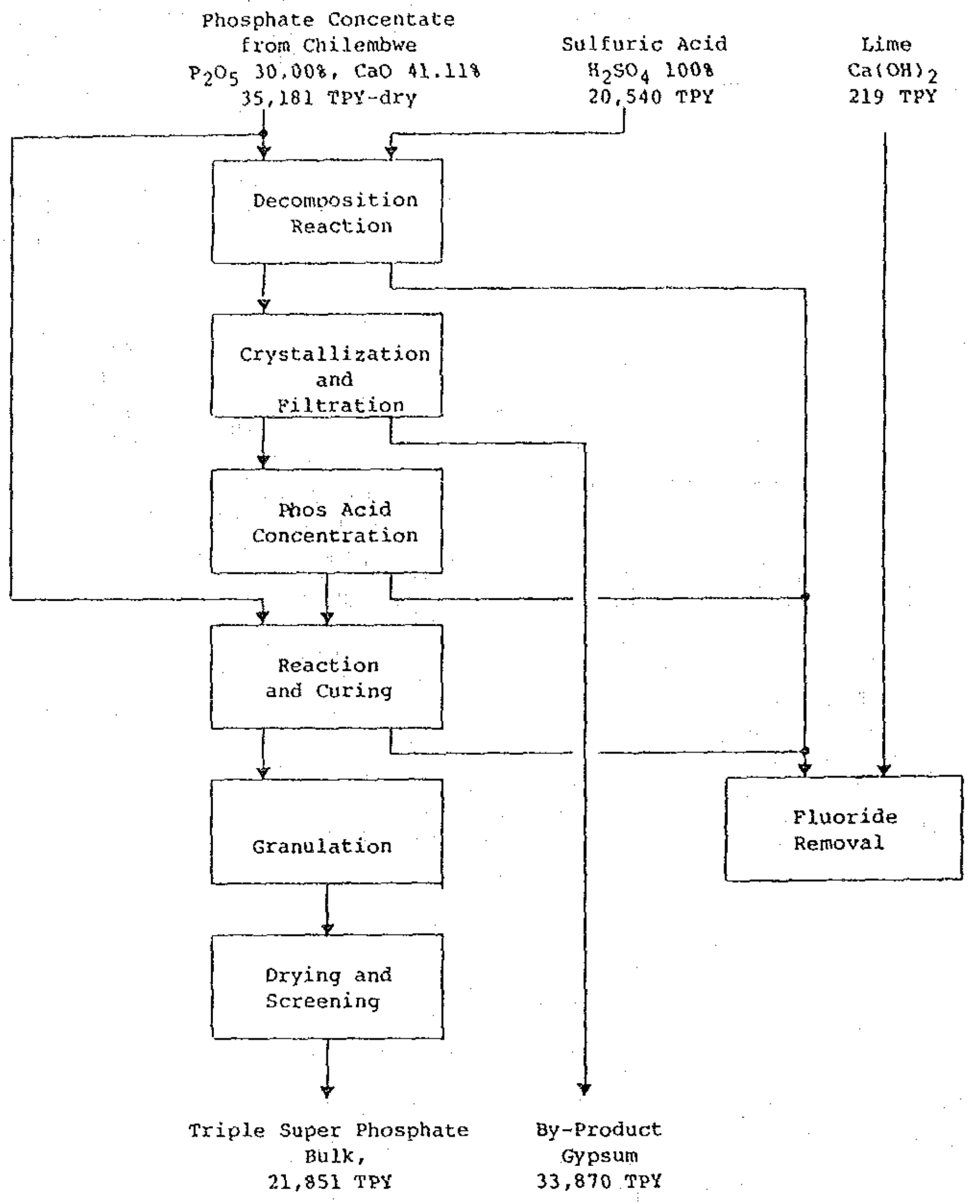
The standard world scale of the process plant at present is 1,000 to 2,000 TPD while the assumed project scale in Zambia is 256 TPD.

6. Material Balance

A simplified block flow diagram for the production of triple super phosphate, diammonium phosphate and nitric phosphate assuming the use of Chilembwe phosphate concentrate are illustrated in the following Figures.

Figure PRODUCT ALTERNATIVE FOR STUDY AND TECHNICAL INFORMATION SUPPLY (1/3)

- Triple Super Phosphate -



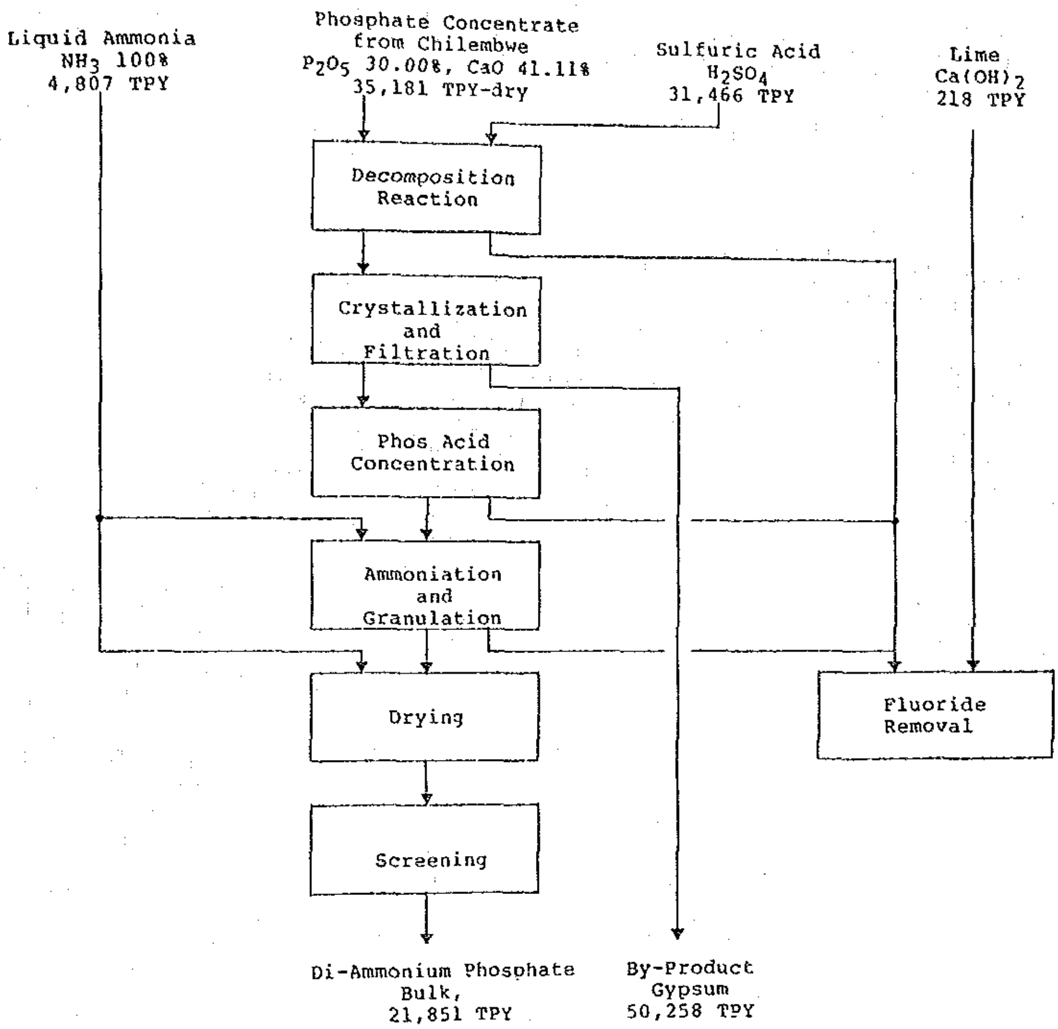
Product Specification	
T- P_2O_5	47.0%
Av-P_2O_5	46.0
W- P_2O_5	40.0
T-S	3.0
Bagging	Bulk

Unit Consumption, TPT	
Phos Concentrate	1.610 Ton
Sulfuric Acid	0.940
Lime	0.010
Anti-Foaming	0.0001
Electricity	75.0 kWh
Fuel	0.030 Ton
Raw Water	2.500

Plant Capacity	
Capacity	72.8 TPD
Site Area	50,000 m^2
Location	Kafue, Zambia

Figure PRODUCT ALTERNATIVE FOR STUDY AND TECHNICAL INFORMATION SUPPLY (2/3)

- Diammonium Phosphate -



Product Specification

T- N	18.0%
T- P_2O_5	47.0
Av-P_2O_5	46.0
W- P_2O_5	40.0
T-S	3.0
Bagging	Bulk

Unit Consumption, TPT

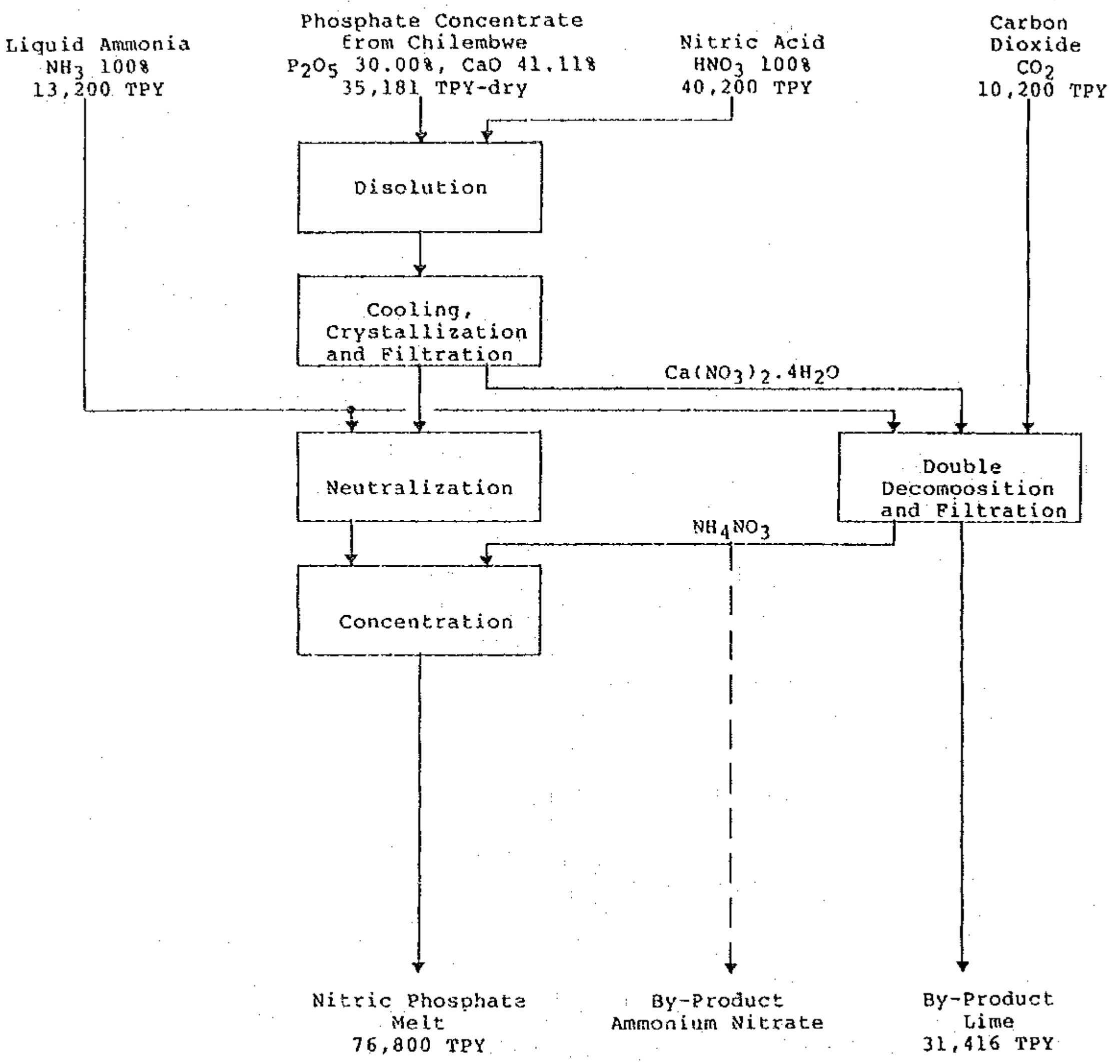
Phos Concentrate	1.610 Ton
Sulfuric Acid	1.440
Ammonia	0.220
Lime	0.010
Anti-Foaming	0.0001
Anti-Caking	0.005
Electricity	85.0 kWh
Fuel	0.040 Ton
Raw Water	3.000

Plant Capacity

Capacity	72.8 TPD
Site Area	50,000 m^2
Location	Kafue, Zambia

Figure PRODUCT ALTERNATIVE FOR STUDY AND TECHNICAL INFORMATION SUPPLY (3/3)

- Nitric Phosphate -



Product Specification	
T- N	24.9%
A- N	14.0
N- N	10.9
T- P_2O_5	13.3
Av-P_2O_5	13.2
W- P_2O_5	10.3
T-S	0.0
Bagging	Bulk

Unit Consumption, TPT	
Phos Concentrate	0.445 Ton
Ammonia	0.172
Nitric Acid	0.524
Carbon Dioxide	0.135
Lime	0.010
Anti-Foaming	0.0001
Anti-Caking	0.005
Electricity	100.0 kWh
Fuel	0.065 Ton
Raw Water	3.500

Plant Capacity	
Capacity	256 TPD
Site Area	50,000 m^2
Location	Kafue, Zambia