FEASIBILITY STUDY REPORT
ON
THE ESTABLISHMENT OF UREA
FERTILIZER PLANT
IN
THE KINGDOM OF NEPAL

SEPTEMBER 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

68.4

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PREFACE

In response to the request of His Majesty's Government of Nepal, the Government of Japan decided to conduct a feasibility study on the Urea Fertilizer Plant Establishment Project and entrusted the Study to the Japan International Coorperation Agency (JICA). The JICA sent to Nepal a team headed by Masayasu SAKANASHI from January 8 to February 5, 1981.

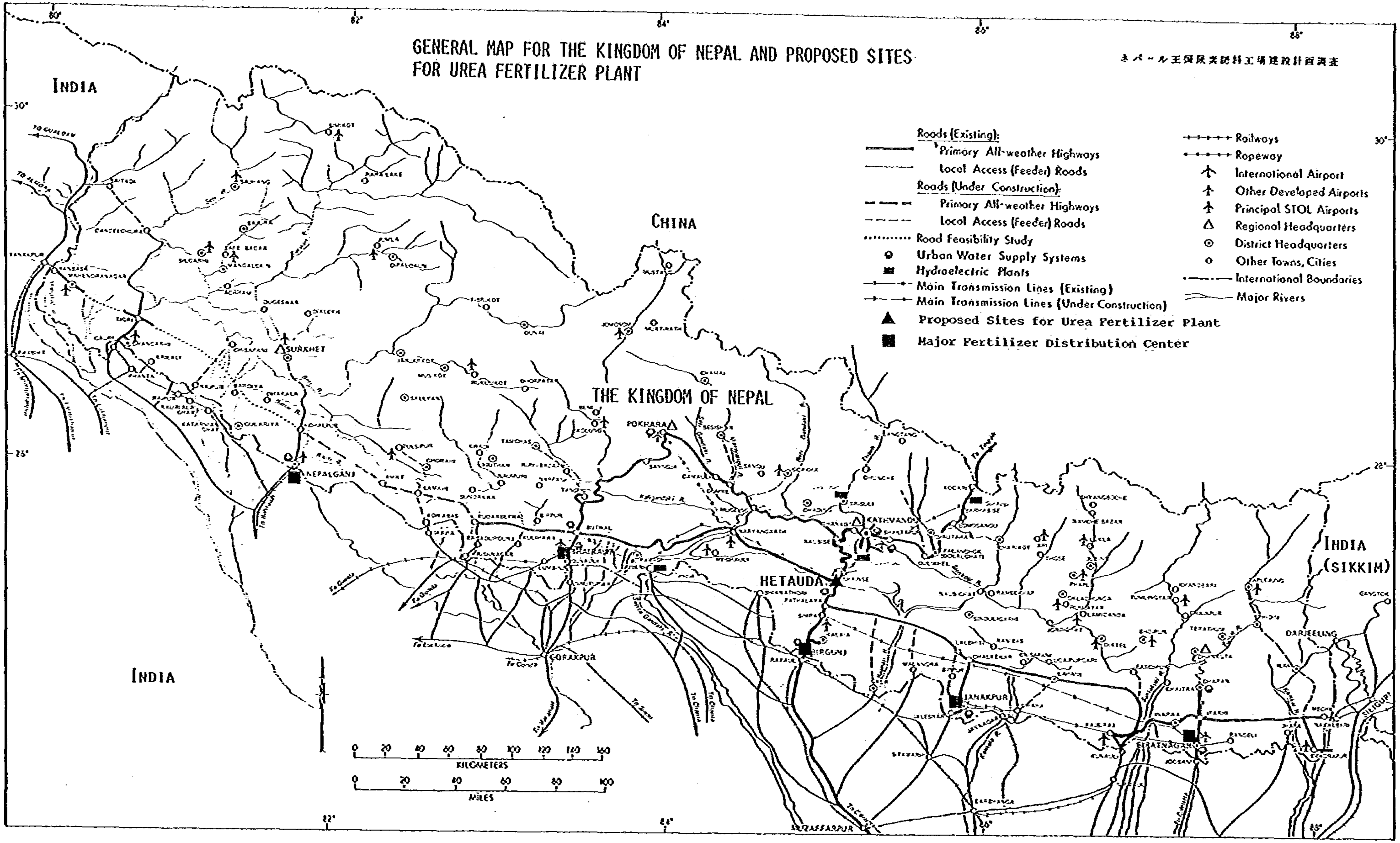
The team exchanged views with the officials concerned of the Government of the Kingdom of Nepal and conducted a field survey in Kathmandu, Pokhara and Hetauda areas. After the team returned to Japan, further studies were made and the present report has been prepared.

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

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

Tokyo, September 1981

Keisuke ARITA
President,
Japan International Cooperation Agency



GENERAL MAP FOR THE KINGDOM OF NEPAL AND PROPOSED SITES
FOR UREA FERTILIZER PLANT
ネパール王国尿素肥料工場建設計画調査
Roads (Existing):
Primary All-weather Highways
Local Access (Feeder) Roads
Roads (Under Construction):
Primary All-weather Highways
Local Access (Feeder) Roads
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Urban Water Supply Systems
Hydroelectric Plants
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Railways
Ropeway
International Airport
Other Developed Airports
Principal STOL Airports
Regional Headquarters
District Headquarters
Other Towns, Cities
International Boundaries
Major Rivers
INDIA
CHINA
THE KINGDOM OF NEPAL
INDIA (SIKKIM)
INDIA
SURKHET
NEPALGANJ
POKHARA
KATHMANDU
HETAUDA
BIRGUNJ
JANAKPUR
BIRATNAGAR
GORAKPUR
DARJEELING
SILIGURI
MUZAFFARPUR
KILOMETERS
0 20 40 60 80 100 120 140 160
MILES
0 20 40 60 80 100

ABBREVIATIONS

General

C & F	Cost & Freight
CIF	Cost, Insurance and Freight
Financial Year	July 16 to July 15 in Nepal
FOB	Free on Board
IRR	Internal Rate of Return
Rs	Nepalese Rupees
ROI	Return on Investment
NPV	Net Present Value
N.A.	Not Available
S/W	Scope of Work
USD	U.S. Dollar
Exchange Rate (Effective Jan. 15, 1984)	USD 1.00 = Rs 15.65 = Yen 230.00 Rp 1.00 = USD 0.06390 = Yen 14.697 Indian Rupee 1.0 = Rs 1.450 (The exchange rate with the US Dollar has been unified since September 19, 1981)

Organization and Others

ADB	Agriculture Development Bank
AIC	Agricultural Inputs Corporation
APROSC	Agricultural Projects Services Center
AMC	Agricultural Marketing Corporation
CEDA	Center for Economic Development and Administration, Tibhuvan University
CDR	Central Development Region (Bagmati, Janakpur and Narayani, The Kathmandu Valley is a portion of Bagmati)
CIDB	Cottage and Village Industries Development Board
DADO	District Agricultural Development Officer
DCVI	Department of Cottage and Village Industries
DOMG	Department of Mines and Geology
Dooars	Dooars Transport (Private) Ltd.
ED	Electricity Department
EDR	Eastern Development Region (Mechi, Kosi and Sagarmatha)
EEC	Eastern Electricity Corporation
FAO	Food and Agriculture Organization

FWDR	Far Western Development Region (Seti and Mahakali)
The Fifth Plan	The Fifth Development Plan (1975 to 1980)
Godown	Storage House
The Hills	The Mahabharat Hills of Nepal
The Himalayas	The North Mountain Area of Nepal
HMG	His Majesty's Government
HMGN, HMG/N	His Majesty's Government of Nepal
HCC	Himal Cement Co. (PVT) Ltd.
HCI	Hetauda Cement Industries Ltd.
IAAS	Institute of Agriculture and Animal Science
IPB	Industrial Promotion Board
IR	Indian Railways
ISC	Industrial Services Centre
JDBN	Jute Development Board of Nepal
JICA	Japan International Cooperation Agency
JT/JTA	Junior Technician/Junior Technical Assistant under
MFAI	Ministry of Food, Agriculture and Irrigation
MOF	Ministry of Finance
MOI	Ministry of Industry
MOWR/MWR	Ministry of Water Resources
MWDR	Mid Western Development Region (Rapti, Karnali and Bhari)
NBL	Nepal Bank Limited
NBOS	Nepal Bureau of Standard
NBM	Nepal Bureau of Mines
NEC	Nepal Electricity Corporation
NFC	Nepal Food Corporation
NIDC	Nepal Industrial Development Corporation
NIS	Nepal Institute of Standards
NPC	National Planning Commission
NRB	Nepal Rastra Bank
NTC	Nepal Transport Corporation
Panchayat	Local Organization at Village Level
Sajha, Saja	Cooperative Societies
SHDB	Small Hydel Development Board
The Sixth Plan	The Sixth Development Plan (1981 to 1986)
The Terai	South low lands plain of Nepal
TCN	Transport Corporation of Nepal
UCI	Udayapur Cement Industries Ltd.
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Program
WDR	Western Development Region (Dhaulagiri, Gandakiand Lumbini)

Units

Acre, A	1 Acre = 4,047 m^2
ata, atg	Atomospheric Pressure Absolute, Gauge
BBL	Barrel
BSCF, BCF	Billion SCF
BSCFD	Billion SCF per Day
BTU	British Thermal Unit, 1.0 BTU = 0.252 Kcal
Bushel	1.0 Bushel = 34.25 Liters
Crore	1.0 Crore = 10.0 Million
DWT	Deadweight Ton
EL	Elevation Level
Ha	Hectare, 1 ha = 10,000m^2 = 2,471 Acres (A)
HHV	High Heating Value
GW	Giga Watt, Billion Watt
Gallon	1.0 US Gallon = 0.003785 m^3
Katha	1.0 Katha = 0.666 Ropani = 339.158 m^2
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-Hour = 3.413 BTU
Lakh	1.0 Lakh = 100,000
LHV	Low Heating Value
MW	Mega Watt, Million Watt
MMBTU	Million BTU
MMSCF	Million SCF
MMSCFD	Million SCF per Day
MSCF	Thousand SCF
MSL	Mean Sea Level
Nm^3	Normal Cubic Meter measured at 0°C and 1.0 atm.
psi	Pound per Square Inch 1.0 psi = 0.07031 kg/cm^2
Ropani	1.0 Ropani = 508.737 m^2 = 5,476 ft^2
SCF, CF	Standard Cubic Feet measured at 60°F and 14.7 lb/in^2 1.0 SCF = 0.0283 Nm^3
SCFD, CFD	Standard Cubic Feet per Day
STB	Standard Tankage Barrel 1.0 STB = 159 Litre (60°F)
TSCF, TCF	Trillion SCF
TPD	Ton per Day
TPH	Ton per Hour
TPT	Ton per Ton
TPY	Ton per Year
Ton, ton	Metric Ton

Fertilizer

AN	Ammonium Nitrate Fertilizer
AS	Ammonium Sulfate Fertilizer
BPL	Bone Phosphate of Lime in terms of $Ca_3(PO_4)_2$, $BPL/P_2O_5 = 2.1853$
CAN	Calcium Ammonium Nitrate Fertilizer
CN	Calcium Nitrate Fertilizer
CX	Complex Fertilizer
DAP	Diammonium Phosphate Fertilizer
N	Nitrogen nutrient expressed in terms of N
NP/NPK	Compound Fertilizer or Complex Fertilizer
MAP	Monoammonium Phosphate Fertilizer
MOP	Muriate of Potash, Potassium Chloride Fertilizer
SOP	Sulfate of Potash, Potassium Sulfate Fertilizer
Urea	Urea Fertilizer

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SUMMARY, CONCLUSION AND RECOMMENDATIONS

Chapter 1 Outline of the Project

1-1 Outline of the project

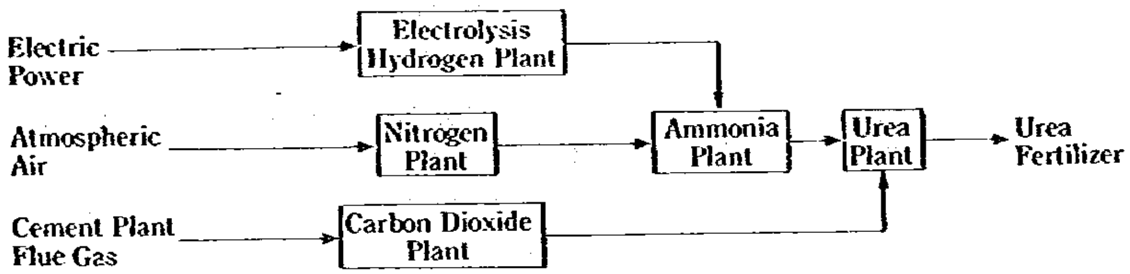
The outline of the project for the establishment of a urea fertilizer plant in the Kingdom of Nepal proposed as the conclusion of this study, is to construct a urea fertilizer plant with a 275 TPD capacity which would be located in Hetauda and targeted to be on-stream in 1991.

The production process applied for urea synthesis is to react ammonia from water electrolysis hydrogen utilizing surplus electric power (secondary energy) generated in accordance with the development of hydropower plant projects in Nepal with carbon dioxide recovered from the cement plant flue gas. The product urea fertilizer is sold in domestic market in Nepal.

The outline of the project is described hereunder;

(1) Production process

Major process scheme of urea fertilizer production is as follows:



(2) Production capacity, and raw material and utility consumption

Item	Quantity	Supply
Raw Material and Utility		
— Electric Power	76.1 mw	Nepal Electricity Corp.
— Industrial Water	4,800 TPD	Self Supply (free of chrge)
— Atmospheric Air	19,000 Nm^3PH	Self Supply (free of charge)
— Cement Plant Flue Gas	32,450 Nm^3PH	Hetauda Cement Ind., Ltd. (free of charge)
— Coal	76.8 TPD	Import from India
— Fertlizer Bag	6,060 Sheet PD	Nepal domestic product
Product		
— Urea Fertilizer, Bagged	275 TPD	Sell to Agricultural Inputs Corp.

(3) Project execution organization

It is assumed that a new state organization would be established for the promotion of the project as a national project, and simultaneously seek technical assistance of internationally experienced consultants for the execution of the proposed project.

(4) Project location

A new site of 500 m × 200 m area would be developed at the west side of the cement plant of Hetauda Cement Ind., Ltd. in Hetauda for the construction of the urea fertilizer plant.

(5) Plant construction schedule

It is assumed that the plant construction contract would be awarded by international competitive bidding among internationally experienced contractors under a lump-sum and full-turn-key type contract, and the construction schedule is projected as follows:

- Plant construction contract award : January, 1988
- Mechanical completion of plant : January, 1991
- Commencement of commercial production: July, 1991

(6) Organization and personnel

The head office would be located in Kathmandu and the urea fertilizer plant in Hetauda. There would be six departments for general affairs, production, utilities, maintenance, storage and loading, and engineering management with total personnel of 319 including 7 executives.

(7) Product sales plan

All urea fertilizer product would be sold in the domestic market through Agricultural Inputs Corp. The annual sales and price projection are as follows:

Year	Product sales	Product selling price
1991/92	51,500 TPY	US$486/ton
92/93	55,300	520
93/94	59,100	554
94/95	59,100	593
95/96	65,600	632
:	:	:
2000/01	69,700	871

(8) Investment cost required and financing plan

(Unit: US$, Million)

Total Project Cost		Financing Plan	
— Foreign currency portion	119.87 (82.8%)	— Equity	43.44 (30%)
— Local currency portion	24.92 (17.2%)	— Loan	101.35 (70%)
Total	144.79	Total	144.79

1-2 Outline of project facility

The urea fertilizer plant would be located in Hetauda and would be designed to be operable continuously as far as possible under constraints of electric power supply (seasonal and hourly fluctuation) and of carbon dioxide supply from the cement plant flue gas.

Major facilities are listed as follows:

(1) Process Plant	
— Hydrogen Plant	28.4 TPD
— Nitrogen Plant	132 TPD
— Ammonia Plant	160 TPD
— Carbon Dioxide Plant	207 TPD
— Urea Plant	275 TPD
(2) Storage Facility	
— Hydroen Gas	33,000 Nm^3
— Nitrogen Gas	2,000 Nm^3
— Ammonia	1,750 ton
— Carbon Dioxide Gas	20,000 Nm^3
— Urea Fertilizer	
— Bagging Facility	40 TPD
— Loading Facility	100 TPD
— Bulk Storage	2,100 ton
— Bagged Storage	7,000 ton
(3) Utility Facility	
— Electric Power Receiving	86 MW
— Raw Water Treatment	183 TPH
— Water Demineralizer	32 TPH
— Cooling Water Tower	6,500 TPH
— Steam Generator	27.5 TPH
— Instrument and Plant Air	1,500 Nm^3PH
— Emergency Power Generator	0.8 MW
(4) Auxiliary Facility	
— Administration Buidling	800 m^2
— Maintenance Office	400 m^2
— Maintenance Shop	1,320 m^2
— Analytical Laboratory	400 m^2
— Chemicals and Spare Parts Storage	320 m^2
— Canteen	800 m^2
— Guard House	30 m^2
— Parking Lot	150 m^2
— Medical room	200 m^2
— Plant Laboratory	30 m^2
(5) Off-site Facility	
— Housing Colony (92 Houses)	6,010 m^2

The site area of the urea fertilizer plant is 200 m × 500 m and it is located at the west side of HCI, Hetauda.

1-3 Financial analysis and economic evaluation

(1) Financial analysis

The financial projections of the project have been prepared in the form of pro-forma financial statements, and on the basis of the projected financial statements the financial analysis of the project has been made. The results of the analysis are summarized below.

	IRR in current prices (%)		IRR in constant prices (%)	
Electricity Price	Before tax	After tax	Before tax	After tax
— 80% of the base estimate	3.70	3.06	*	*
— 60% of the base estimate	8.17	6.16	2.23	0.37
— 40% of the base estimate	11.78	9.38	5.59	3.36
— 20% of the base estimate	14.87	12.24	8.48	6.02
— No value	17.61	14.84	11.03	8.44

Note *: negative returns

The above analysis, as the base estimate, uses a 1984 electricity price of US¢3.56/kWh calculated on the basis of the present tariff and escalated at 6% per annum.

(2) Economic evaluation

The results of the economic assessment of the project are presented by means of the following indicators.

— Economic internal rate of return (ERR)	8.2%
— Economic net present value (ENPV)	US$1.08 millions in 1984 constant price terms (at 8% discount rate)
— Net foreign exchange savings	US$37.38 millions/year (average in 15 years)
— Net value added ratio	54.0% of annual production cost (average in 15 years)
— Creation of employment opportunities (direct and indirect)	400 persons

The analysis of ERR uses the economic electricity cost of US¢1.182/kWh which has been calculated on the basis of the long run marginal cost for energy (LRMC) estimated as US¢6.82/kWh for firm energy and US¢1.17/kWh for secondary energy, in 1984 constant price terms, by referring to the capital cost for the Sapta Gandaki hydropower project, and also taking into account of the consumption pattern of firm energy and secondary energy for the project.

It must be further noted that the net foreign exchange savings and the net value added ratio (ratio of domestic costs in the production costs) have been calculated on the assumption that the electricity is supplied at a rate set as 40% of the present tariff level. As far as this assumption applies, the production cost will be lower than the import prices except for the initial three years. On the other hand, the foreign exchange cost will always be lower than the import prices.

Chapter 2 Summary of the Study Results

2-1 Agriculture and fertilizer markets in Nepal

(1) Overview of fertilizer consumption

In 1982/83 the fertilizer consumption in Nepal was 22,900 N tons of nitrogen fertilizer, 7,200 P_2O_5 tons of phosphate fertilizer, and 900 K_2O tons of potassium fertilizer. Among them, consumption of nitrogen fertilizer has increased steadily with an annual growth of 17% averaged for the period from 1966/67 to 1982/83, while that of phosphate fertilizer has stagnated, and that of potassium fertilizer showed a decrease in recent years.

Ratios of phosphate and potassium consumption against nitrogen consumption were 1:0.3:0.01 ($N:P_2O_5 : K_2O$), which demonstrates a high ratio of nitrogen consumption compared to that of phosphate and potassium fertilizer. Nevertheless Nepal's consumption of nitrogen fertilizer per hectare of arable land was only 7.4 N kg/ha, which is low compared to the world average or that of other countries in South-West Asia (Table 1 and Figure 1).

In view of the past trend of nitrogen consumption in Nepal, during the period of 1973 through 1975, the consumption growth stagnated due to the price hike of imported fertilizer caused by the oil crisis, but thereafter the consumption has increased at 13% per annum in average.

In reviewing the past consumption trend of nitrogen fertilizer by type, the consumption of ammonium sulphate accounted for around 70% of total nitrogen consumption until the latter half of the 1960's, but with the consumption of urea having increased gradually it accounted for more than 60% in the latter half of 1970's, and further it exceeded 65% in 1980 through 1982. By contrast, the consumption of ammonium sulphate shrank to around 5% of the total, whereas that of compound fertilizer accounted for about 25% (Table 2). However, it was often found that farmers were compelled to use compound fertilizer without regard to their preference because other types of nitrogen fertilizer required by them were not available.

(2) Cultivation practice and fertilizer application

The agriculture in Nepal can be grouped into the following three regions on the basis of geographic characteristics, as well as regional characteristics for transportation and distribution in the country.

A. Terai area which is a plains area located along the border with India

B. Kathmandu Valley area developed on the outskirt of Kathmandu and the hill areas along the main roads in Nepal

C. Inaccessible remote hill and high hill areas

Nepal's principal crops are cereal including rice, maize, wheat and millet; jute; oil seeds; tobacco; and potato. Rice accounts for 64% of total cereal production, and is grown mainly in Terai and Kathmandu Valley. Rice is the rainy season crop in low land areas, while up-land rice, maize and millet are the rainy season crop in hill areas. Wheat, barley, buckwheat and beans are the typical winter crops. In addition to rice, jute is an important export crop mainly grown in Eastern Terai. Tobacco is grown in Central and Eastern Terai mainly for the domestic market, and sugarcane is grown in Central Terai, also for domestic use. Potato is grown throughout the country, and used for own-consumption as a supplementary crop of rice and maize (Table 3).

It is estimated that fertilizer consumption broadly consists of 50% for wheat, 35% for rice, and the remaining 15% for other crops. As most wheat grown is that of improved varieties which have extremely low yield if there is no fertilization, this crop uses a greater quantity of fertilizer than does for rice. Most rice is grown in the rain-fed areas, although there are irrigated fields in some areas. In these irrigated areas, as stable yields can be gained, fertilizer is widely applied. In contrast, in the rain-fed area, farmers have less incentive to accept an increase in input costs for improving production, because of unstable yields. For cereals except wheat and rice, little fertilizer is used. Sugarcane and tobacco are grown as cash crops by fairly large scale farmers, and fertilizer is generally applied on these crops.

In regard to regional distribution of the nitrogen fertilizer consumption, around 80% of the total was consumed in Kathmandu Valley and Terai areas, and the consumption in High Hill and Hill areas accounted only for 20%. Central Terai and Kathmandu Valley are the largest consumption areas in Nepal, consuming 32% and 30% of total, respectively.

(3) Outlook of factors affecting nitrogen fertilizer demand

Among the various factors which are considered to influence Nepal's demand for nitrogen fertilizer, the major ones are as follows:

A. Economics of fertilizer use

B. Availability of irrigation and/or drainage facilities

C. Development and diffusion of high-yielding varieties

D. Purchasing ability of farmers and/or availability of credit systems for fertilizer purchase

E. Possibility of timely supply of fertilizer

F. Knowledge on the effects of fertilizer on yield

The outlook for these factors would form the basis for forecasting fertilizer demand in future. The fertilized area ratio (ratio of fertilized area to cultivated area) estimated for major crops is 12% for rice, 59% for wheat, and 3% for maize. In the case of sugarcane, tobacco and jute, all the cropped areas are likely to have received fertilizer. Ratio of the fertilized area to the cultivation area of improved varieties is estimated as only 16% for maize against 70 to 85% for rice and wheat. In the case of rice, the improved varieties have high importance for fertilizer use as compared to the local varieties, and the diffusion of improved varieties therefore is essential for promotion of fertilizer use. Farmers cultivating the improved varieties of wheat and maize have the potentiality to increase the application of fertilizer up to the recommendation level. The diffusion rates of improved varieties to total cultivation area in the past were 18% for rice, 15% for maize, and 85% for wheat. In the case of rice and maize, as there are several factors hampering the diffusion of improved varieties, a rapid growth of their cultivation can not be expected.

Expansion of irrigated farms is another factor for promoting fertilizer consumption. At present, however, the area of irrigated farms accounts for around 10% of arable land (approximately 2.3 million ha.). The area of irrigated farms can be expected to increase gradually, and the fertilized area would also increase accordingly. Most farmers have weak purchasing power. In order to create a stable demand for fertilizer, improvement of the credit system is essential. However, although the present system is insufficient, there is no plan to improve the system. This situation may limit the results of future efforts to increase fertilizer consumption. In Nepal fertilizer supply often fails to be delivered in a timely manner, and this has been the great impediment constraining fertilizer use in the remote areas. The construction of roads will continue in the future and accessible areas may be expected to be expanded gradually. Further, once the domestic production of fertilizer starts, the distribution plan may become well organized so that it can contribute to promoting of increases in fertilizer consumption. Extension services at present are insufficient. The services may be improved gradually, but immediate improvement can not be expected.

(4) Outlook of demand for nitrogen fertilizer, and projected sales

Shown below is the future demand for nitrogen fertilizer in Nepal which has been forecasted by taking the foregoing outlook into account (Table 4 and Figure 2).

Year	Demand (1,000 N tons)
1982	20.9
1985	22.5
1990	27.3
1995	32.3
2000	33.4

As stated earlier, urea is predominantly used at present. It is judged from the agronomical point of view that urea is the most suitable type of nitrogen fertilizer for use in Nepal. Although compound fertilizer has been used to some extent, it has not necessarily represented farmers' preference of fertilizer type. Therefore it may be possible to convince farmers to use urea. The sales of urea projected by taking these factors into account is as follows (Table 5).

Year	Urea demand (tons in product)
1990	44,500
1995	63,200
2000	69,000

(5) Marketing and distribution of urea

HMG/N put fertilizer importation and distribution under its control, and the Agricultural Inputs Corporation (AIC), a state-owned corporation handles it exclusively. In retail markets, except some areas where private retailers handle fertilizer distribution, HMG/N guides the unit cooperatives so that they handle the distribution as much as possible. It is anticipated that this system will continue in the future. AIC has fertilizer storages throughout the country. It is possible to perform well-organized distribution by utilizing those storages.

(6) Sales price of urea fertilizer

HMG/H sets the fertilizer price at a uniform level for all the country. In case that the official price is lower than the actual costs for imports and distribution, and also that the fertilizer is distributed to Hill and High Hill areas requiring costly transportation, HMG/N provides AIC with subsidies to compensate for any losses incurred.

When the urea fertilizer plant is built, the sales price to AIC may be determined by the authority of HMG/N. Hence it might not be appropriate to predict the future price based on the prevailing prices in Nepal, but it may be appropriate to forecast the price based on the prices for imported fertilizer. The following is the ex-factory urea sales price projected on the foregoing assumptions.

Calendar Year	Projected sales price (US$/ton in bagged)	
	1981 Cosntant Prices	Current Prices
1983	260	245
1985	286	303
1990	319	453
1991	322	481
1995	332	630
2000	342	869

2-2 Technical aspects

(1) Outline of proposed project

The outline of the proposed project for the establishment of a urea fertilizer plant in Nepal is summarized as follows:

— Product:	— Prilled Urea Fertilizer in Bags
— Production Capacity:	— 275 TPD
— Location:	— Hetauda, Nepal
— Raw Materials and Production Process:	— Ammonia production from water electrolysis hydrogen and air fractionated nitrogen — Carbon dioxide recovery from cement plant flue gas — Urea synthesis from ammonia and carbon dioxide
— Commencement of Commercial Production:	— Mid-1991 (provided that No. 1 of Sapta Gandaki is completed by early 1991)

The above project concepts are derived from the following rationale:

A. Selection of product type

The market study reveals that the consumption of urea fertilizer in Nepal would be the largest among various nitrogen fertilizers in future. Although minor levels of consumption of several other nitrogen fertilizers is anticipated, it is not practical to produce a multiple number of nitrogen fertilizers in one small plant because of economy of scale. Hence it is appropriate to select urea fertilizer as the one fertilizer produced at the first fertilizer plant in Nepal.

B. Raw materials and production processes

The most generally used production process for manufacturing urea is to feed hydrocarbons as major raw materials at an ammonia plant to produce liquid ammonia as well as carbon dioxide, both of which are then supplied as intermediates to a urea plant to produce urea fertilizer.

In Nepal, however, there is no hydrocarbons, such as coal, natural gas, petroleum and biomasses commercially available for the production of ammonia and urea. The only possibility is to produce urea fertilizer based on ammonia produced from hydrogen generated by water electrolysis thereby efficiently utilizing hydropower and water resources, and also on carbon dioxide recovered from cement plant flue gas.

C. Production capacity of urea fertilizer plant

To determine production capacity of the proposed plant, the following three basic factors should be carefully studied:

- Completion year of the plant
- Marketability of the product
- Supply of electric power and carbon dioxide

To improve the economics of the project, it is desirable to establish a maximum scale plant as far as the marketability of the product and also the suppliability of electric power and carbon dioxide permit.

It is also important to include in the design of plant facilities and operational patterns of the urea fertilizer plant countermeasures for the limited suppliability of electric power which can be anticipated due to the monthly supply and demand fluctuations during the year and also hourly fluctuation during a day.

Taking into consideration the above factors, it is concluded that the optimum production capacity is 275 TPD.

D. Target year of commencement of commercial production

Generally it takes at least five years from the start for the planning and construction of a urea fertilizer plant; therefore it is appropriate to target the completion of the plant in 1989 at the earliest. Taking into consideration the marketability of urea and suppliability of electric power in 1989 and onward, it is concluded that the optimum completion year of the plant would be 1991 and the commencement of the commercial production would be from mid-1991.

(2) Supply and demand of electric power and suppliability of electric power for the project

Most electric power generated in Nepal is supplied by the public sector. The Ministry of Water Resources is responsible for the electric power development in Nepal and its Electricity Department is managing the planning and construction of electric power station, and transmission and distribution lines.

The total generating capacity of the public sector is 144 MW of which 84% is by hydropower and 16% is by diesel electric power generators. The capacity in the private sector is 12 MW. In addition, 52 GWh is imported from India in accordance with the Nepal-India Agreement. In 1981/82 the import and export were 57 and 5 GWh respectively, resulting in net import of 52 GWh which is equivalent to 19% of the total supply in Nepal.

The transmission system is the most advanced in the Central Region. In this region there is the trunk line connecting Kathmandu, Hetauda and Birganj which is further linked with the 132 kV line from the Eastern and Western Regions.

The average annual growth rate of electric power supply in Nepal for eleven years from 1970/71 to 1981/82 is 15%, leading to 270 GWh in 1981/82. Traditionally a supply deficit has been observed as electric power developments were delayed. Recently the situation has been improved because of the completion of Kulekhani No. 1; however, it is anticipated that again in a few years supply would be in deficit. The present demand pattern is mostly for household use which has a share of approximately 50% of total demand. Industrial uses need 30%. Anticipating the present and future industrialization plans in Nepal, it is thought that the demand pattern of electric power would show a similar situation in future.

The demand increase projected at the Electricity Department of Nepal is summarized as follows:

Projected Electric Power Demand in Nepal

	Annual demand		Peak demand		
Year	Demand, GWh	Average annual growth, %	Demand, MW	Average annual growth, %	Average Load factor
1982/83	284.9	—	67.8	—	0.48
1992/93	1,299.4	16.4	293.1	15.8	0.51
2001/02	3,345.5	11.1	723.3	10.6	0.53

Note: Electric power demand for the urea fertilizer plant is not included.

The Electricity Department is now implementing the construction of Kulekhani No. 2 (32 MW) and Andhikhola (5 MW), and has decided on the construction of the Marsyangdi (66 MW) hydropower plant. After the completion of these three plants, the total generating capacity of Nepal in 1988/89 would be 255 MW and its annual supply would be 1,181.5 GWh.

Succeeding to these projects, the construction of Sapta Gandaki (225 MW) is planned. Although the completion date of the plant has not yet been fixed, the Electricity Department is targeting the completion of No. 1, No. 2 and No. 3 of Sapta Gandaki in 1991/92, 1992/93 and 1993/94, respectively.

Taking into consideration the above demand projection and also development plans, it is anticipated that the supply and demand would be improved temporarily in 1988/89 but again it would be tightened in 1990/1991 onward if the completion of Sapta Gandaki is delayed. The implementation of Sapta Gandaki will have great impact on future electric power supply regardless of the implementation of a urea fertilizer plant project in Nepal (Refer to Figure 3).

The increased demand would be supplied from Sapta Gandaki by 1995/96 if the completion of Sapta Gandaki is realized as targeted, however after that the deficit situation would be chronic if the post-Sapta Gandaki hydropower projcts would not be implemented.

Although in Nepal the potential for the development of new hydropower projects is high enough to meet the electric power demand increase in the future, there are some possibilities for delays in realization. It is recommended that the decision should be made by HMG/N for the promotion of the urea fertilizer plant project in view of its judgement on the certainty of long term electric power suppliability in future because a long term supply assurance of electric power is a basic premise for the existence of a urea fertilizer plant.

Major existing hydropower plants in Nepal are of the run-of-river type and therefore there is a big difference in supply of electric power between dry season and wet season. On the other hand, the demand increases during the dry season and the supply and demand situation is tightened in the dry season every year.

The hydropower plants which will be constructed in the future are also basically run-of-river type and therefore the possibility for great improvement of such a situation is also low in the future. Under such situations, it is anticipated that a large surplus of electric power would be observed during the rainy season in contrast to the tight and deficit situation in the dry season.

There is an extreme difference in demand between peak hours and off-peak hours in a day, and the average load factor against the daily maximum is from 50 to 60%. These phenomena are due to the fact that the household demand share is the largest component of demand in Nepal and it is considered that such phenomena would also exist in future.

The expected electric power consumption by the urea fertilizer plant project is as follows according to the capacity of the plant:

Daily production capacity of urea fertilizer plant	Electric power consumption		
	Hourly	Daily (24 hours)	Monthly (30 days)
	(MW)	(MWh)	(GWh)
– 100 TPD	27.68	664.2	19.93
– 200 TPD	55.35	1,328.4	39.85
– 300 TPD	83.03	1,992.6	59.78

Note: Unit consumption is 6,642 kWh/ton of urea fertilizer

Basically it is taken for granted that the operation of the urea fertilizer plant should be continuous all day long and it is necessary then to supply enough electric power steadily all the year round to maintain stable operation of the plant. Assuming the above mentioned seasonal and hourly fluctuations of electric power surplus, there is insufficient suppliability of electric power even for a small scale urea fertilizer plant (100 TPD capacity) when the Marsyangdi hydropower plant is completed in 1988/89 and therefore the urea fertilizer plant project should be implemented so as to meet the completion of No. 1 of Sapta Gandaki hydropower plant.

After the completion of Sapta Gandaki, a large amount of surplus energy would be generated except during a few months in the dry season for at least seven years, and therefore it is possible to operate a urea fertilizer plant having up to 300 TPD capacity for nine to ten months continuously every year.

However from 1997/98, the supply again would be tight, and therefore assurances of the completion for not only Sapta Gandaki but also the subsequent post-Sapta Gandaki projects are required.

It is also required to allow for the annual maintenance shut-down of the urea fertilizer plant as well as for closing down the whole plant completely for a few months during the dry season when the electric power supply is tight. The urea fertilizer plant should be designed to be operable even at lower operation loads under the limited supply conditions of electric power.

It is necessary to utilize surplus electric power as far as possible by planning facility design and operation pattern of the urea fertilizer plant as mentioned above and to eliminate any influence on peak demand of electric power. It may be possible, if electric power is supplied from diesel power plants with high priority to the urea fertilizer plant, to increase the operability to some extent but not enough to maintain stable operation at full production capacity.

(3) Supply source of carbon dioxide and its suppliability

For the production of urea fertilizer, a long term and stable supply of carbon dioxide is also essential. The unit consumption of carbon dioxide for urea fertilizer production is 0.75 ton/ton of urea; therefore it is required to secure a supply source of carbon dioxide with 207 TPD capacity to match the urea fertilizer plant with 275 TPD as is proposed for Nepal. The supply source of carbon dioxide for industrial uses in Nepal is limited to the dilute carbon dioxide contained in flue gas from cement plant, which can be recovered by absorption processes using hot carbonate or organic amines solution.

There are two potential sources of cement plant flue gas in Nepal:

A. Himal Cement Co. (PVT) Ltd. (HCC)

— Production Capacity	: 160 TPD of clinker
— Production Performance	: 124.4 TPD of clinker 132 TPD of bagged cement
— Production Process	: Black Meal Shaft Kiln
— Production Process	: Black Meat Shaft Klin
— Plant Location	: Chobar, Kathmandu
— Present Status	: In operation (Last 7 years)

B. Hetauda Cement Ind., Ltd. (HCI)

— Production Capacity	:	730 TPD of clinker
— Production Process	:	Suspension Pre-heater Dry Rotary Kiln
— Plant Location	:	Hetauda
— Present Status	:	Under Construction (Expected completion by the end of 1984)

The flue gas from HCC is at present not suitable in quality and in quantity as a supply source of carbon dioxide to a urea fertilizer plant with 275 TPD capacity. Although HCC has an expansion plan which will be completed in 1986 and the suppliability of carbon dioxide will be increased to two and a half times, enough for a urea fertilizer plant with 355 TPD capacity upon the completion of the expansion plan but quality-wise there is no possibility for improvement.

The cement plant at HCI has not yet been put on-stream and as the specification of raw materials and fuel have not been fixed, it is impossible at present to specify the supply conditions of flue gas to the urea fertilizer plant. However, it is estimated that the suppliability of carbon dioxide in quantity is large enough for the proposed urea fertilizer plant with a 275 TPD capacity.

It is also anticipated that the quality of flue gas is favorable as the carbon dioxide source for the urea fertilizer plant judging from the process scheme of cement production. Therefore the utilization of flue gas at HCI is proposed because the supply conditions at HCI are more favorable than those at HCC.

(4) Proposed site for urea fertilizer plant

As is explained above the supply of carbon dioxide is from the cement plant flue gas at HCI, therefore the site for the urea fertilizer plant must be located in the vicinity of the HCI cement plant site in Hetauda.

It is concluded from the comparison study between Chobar, Kathmandu and Hetauda that the Hetauda location is more favorable at not only regarding supply conditions of carbon dioxide but also the various site conditions required for the urea fertilizer plant. Therefore it is proposed to establish the urea fertilizer plant in the vicinity of HCI in Hetauda. The major reasons are explained as follows:

A. The distance between proposed site and transmission line of electric power is shorter in Hetauda and also reliability of electric power supply is greater in Hetauda.

B. An ample supply of high quality industrial water is obtainable in Hetauda.

C. Enough land area for the proposed plant is available, and soil conditions are favorable, in Hetauda.

D. Transport of equipment and construction materials is easy and economical as the Hetauda site is located in shorter distance for transport from Calcutta, the port of entry.

E. Physical distribution of product urea fertilizer is more easily accomplished from Hetauda.

F. Infrastructure is well developed in Hetauda.

(5) Outline of the urea fertilizer plant

The outline of major facilities of the proposed urea fertilizer plant are described hereunder. The facilities are designed to be operable at the minimum of 50% of daily capacity utilization and to maintain continuous operation as far as possible under supply constraints of electric power (seasonal and hourly fluctuation) and also supply fluctuation of carbon dioxide at the cement plant.

A.	**Process plant**	
	— Hydrogen Plant	28.4 TPD
	— Nitrogen Plant	132 TPD
	— Ammonia Plant	160 TPD
	— Carbon Dioxide Plant	207 TPD
	— Urea Plant	275 TPD
B.	**Storage facility**	
	— Hydrogen Gas	33,000 Nm^3
	— Nitrogen Gas	2,000 Nm^3
	— Ammonia	1,750 ton
	— Carbon Dioxide Gas	20,000 Nm^3
	— Urea Fertilizer	
	— Bagging	40 TPH
	— Loading	100 TPH
	— Bulk Storage	2,100 ton
	— BaggedStorage	7,000 ton
C.	**Utility facility**	
	— Electric Power Receiving	86 MW
	— Water Treatment	183 TPH
	— Water Demineralizer	32 TPH
	— Cooling Water Tower	6,500 TPH
	— Steam Generation	27.5 TPH
	— Instrument and Plant Air	1,500 Nm^3PH
	— Emergency Power Generation	0.8 MW
D.	**Auxiliary facility**	
	— Administration Building	800 m^2
	— Maintenance Office	400 m^2
	— Maintenance Shop	1,320 m^2
	— Analytical Laboratory	400 m^2
	— Chemicals and Spare Parts Storage	320 m^2
	— Canteen	800 m^2
	— Guard House	30 m^2
	— Parking Lot	150 m^2
	— Medical Room	200 m^2
	— Plant Laboratory	30 m^2

E. Off-site facility

— Housing Colony (92 Houses) 6,010 m²

The area of the urea fertilizer plant site is 200 m × 500 m and is west of HCI, Hetauda.

(6) Implementation and management of the urea fertilizer plant project

The entity which will implement the urea fertilizer plant project has not yet been established.

Although the basic policy of the HMG/N has not yet been formulated, it is assumed that the project would be executed by a new state organization, judging from the specific features of the project, once the project is approved by HMG/N.

It is also assumed that the new state execution body would be organized and managed by appointing experienced specialists for implementing an industrial project in Nepal and also by engaging internationally experienced consultants from the foreign countries.

It is considered safe and practical to assume that the construction contract of the urea fertilizer plant would be awarded by competitive bidding among experienced and qualified foreign contractors under a turn-key and lump-sum type contract because of the specific nature of the project. It is important to prepare counter-measures to eliminate any risks and disadvantages generally associated with such type of contract.

The construction schedule assumes that the plant construction contract award would be in January, 1988, the plant completion would be in January, 1991 and the commencement of commercial production would be in July, 1991.

The managerial organization of the urea fertilizer plant is assumed to be at the head office in Kathmandu. The plant organization at Hetauda would have six departments for general affairs, production, utilities, maintenance, product storage and loading, and engineering management. The total number of personnel required is 319 including 7 executives. The product urea fertilizer is assumed to be sold at the Hetauda plant to the AIC.

(7) Technical assistance services required for plant construction and operation

It is observed that in connection with implementation of the project, the entity to execute the project may need to secure technical assistance services by retaining internationally experienced consultants for preparation of plans as well as supervision of plant construction and commercial operation of the plant.

Major activities required at each stage of the project implementation are summarized as follows:

A. Necessary services prior to plant construction contract award

- Detailed study on the site conditions and final selection of plant site
- Detailed study on the suppliability of cement plant flue gas at HCI, Hetauda after the commencement of the operation
- Preparation of invitation for bid for the construction contract of urea fertilizer plant
- Prequalification of contractors
- Preparation of execution plan of the project, schedule, budget and manning plans
- Evaluation of construction contract proposals and negotiation for contract award

B. Necessary services during construction of plant

- Reviewing and checking of the basic and detailed designs submitted by the contractor for owner's approval and provision of instruction to the contractor in regard to any revision of the design
- Monitoring and controlling the progress of activities, such as schedule and budget control and also reporting to the government organization and financial institutions
- Establishing an organization for the start-up and training for the subsequent operation and maintenance

C. Necessary services during early commercial operation stage

- Commissioning of the plant
- Establishment of operation and maintenance systems
- Arrangement for the assignment of responsibilities as well as standard operating procedures
- Implementation of routine tasks through on-the-job training

It will be highly efficient to obtain the systematically organized technical assistance services of an internationally experienced firm for at least two years after the commencement of commercial production, and a budget for this is allocated in the project cost estimates in this study.

2-3 Financial analysis and economic evaluation

(1) Estimates of total financing requirement

The total financing required for completion of project, including contingency, pre-operation expenses, initial working capital, and interest during construction, is estimated as follows.

		(US$, Millions)
Foreign exchange portion	:	119.87
Local currency portion	:	24.92
Total financing required	:	144.79

The major assumptions used for the above estimates are summarized below;

A. Project schedule

- Commencement: Early-1988
- Completion (commencement of commercial operation): Mid-1991

B. Base project cost

Estimated on the basis of 1984 prices.

C. Contingency

— Physical contingency: Estimated at 5% of the base project cost

— Price contingency: Escalation of 3.5% p.a. for foreign exchange portion and 6% p.a. for local currency portion

D. Interest during construction

Assuming an equity/debt ratio of 30:70, and also provisionally assuming the following terms and conditions for loans because financing sources have not yet been determined:

—Foreign Loans

Interest:	5% p.a.
Grace period:	Equal to construction period
Repayment period:	15 years after commencement of commercial operation

— Local Loans (taken out only for short term financing)

Interest:	15% p.a.
Repayment:	within one year

The financing plan for the project, formulated on the basis of the total financing requirement as well as the major assumptions as presented above, is summarized below.

(US$, Million)

	Foreign exchange portion	Local currency portion	Total
Equity capital:	18.52	24.92	43.44
Loans:	101.35	—	101.35
Total financing:	119.87	24.92	144.79

(2) Electricity price, and economic electricity cost

Although electricity supply/demand conditions show significant differences between the dry season and rainy seasons, and hourly load also fluctuates to a substantial extent, the present tariff schedule for industrial uses sets a flat rate applied throughout the year without month-of-year or time-of-day rates.

According to the present tariffs, the electricity price for the urea fertilizer plant is estimated as NRs. 0.57/kWh (US¢ 3.56/kWh). The NEC's electricity tariffs are under the control of HMG/N. Before 1981/82, HMG/N had adopted the policy of keeping electricity tariffs at low price levels, and therefore the electricity price that year was as low as 30% of the long run marginal cost for electricity (LRMC), as well as 50% lower than the level required to obtain a 6% rate of return on assets employed. This placed NEC in a very difficult financial position.

The World Bank's appraisal mission for the Marsyangdi hydropower project recommended a 130% increase in tariffs. In 1983, paying attention to this recommendation, HMG/N revised the tariffs upward by 58% in average.

All of the hydropower plants developed to date are small in scale and most are the run-of-river type. Hence the cost for electricity generated is fairly high. However it is likely that the LRMC may decline in the future, because the Sapta Gandaki project and subsequent projects planned to be completed in the 1990's are medium-scale plants having installed capacity greater than 200 MW. The LRMC for the 1990's at a 6% discount rate is estimated as US¢6.82/kWh for firm energy, and US¢1.07/kWh for secondary energy respectively in 1984 constant price terms, which is equivalent to US¢3.87/kWh as a weighted average.

When compared with the estimated LRMC, the present electricity tariff for industrial uses (US¢3.56/kWh) is level at about 50% of the LRMC for firm energy, whereas it is as high as three times of the LRMC for secondary energy because the present tariff has no special rate for such energy. If a special rate for the secondary energy consumers like this project is adopted by taking the LRMC for that energy into account, it would stimulate the demand for secondary energy. At present there is no definite indication of the HMG/N's long term policy for electricity pricing. Nevertheless HMG/N may consider to set a special rate for this project if necessary after reviewing (a) impacts on feasibility of the project which electricity price would cause, and (b) any effects on the electricity sector which the project would produce.

In view of the foregoing situations, the base estimate for the financial analysis uses the price based on the present tariff (US 3.56/kWh) and annually escalated at 6%. At the same time, assuming that a concessional rate is set for the project, sensitivity analysis is made by changing the price level in order to identify an electricity price level which forms the basis for this project as being financially viable. This analysis can serve to provide HMG/N with the basis for determining the electricity price for the project.

The economic analysis of the project is made on the basis of the estimated LRMC as discussed earlier. At peak demand time, the operation of the hydrogen unit will be stopped, while ammonia and urea plants will be operated at a lower load. Further, the plant operation will be entirely shut down for two and a half months during the dry season when the electric power supply condition is tight. By this means, the overwhelming majority of the electricity requirements for the urea fertilizer plant can be met by otherwise unutilized secondary energy. On this assumption, the economic electricity cost for the project, in 1984 constant price terms, is estimated as US¢1.182/kWh. Thus the economic assessment of the project uses the given economic electricity cost.

(3) Operating cost estimate and financial analysis of the project

The production cost for one ton of the urea fertilizer produced, which is based on the electricity price according to the present tariff and assuming 6% annual escalation, and includes interest on loans and depreciation, is estimated, in current price terms, as given below (Table 8).

Year	Electricity price	Electricity cost per ton of urea (A)	Production cost per ton of urea (B)	A/B
	(US¢/kWh)	(US$/ton)	(US$/ton)	(%)
1991/92	5.35	355.3	836.0	42.5
1995/96	6.76	443.0	854.3	51.9
2000/01	9.04	600.4	980.5	61.2
2005/06	12.10	803.7	1,025.6	78.4

The cost level, as shown above, far exceeds the import price forecasted for the respective year. It is essential to lower the electricity price, as well as to adopt electrolysis technology which requires minimum electricity consumption, in order to make the urea fertilizer production cost comparable to the price for imports. In this study, several types of commercially proven electrolysis technologies have been studied, and as a result the production cost has been estimated by assuming the adoption of an electrolysis technology which has demonstrated the most efficient performance. Hence the only possible measure to reduce the production cost should be to lower the electricity price. Based on the thus estimated production cost, the financial projections of the project have been prepared in the form of pro-forma financial statements for the 15 years economic life, and the financial analysis has been made according to the projected financial statements. The results of the analysis are summarized below.

A. Anual income

The annual revenue of the project has been calculated in accordance with the projected sales and selling price which have been forecasted in the market study. The projection indicates that the revenue will be US$25.0 million in the first year (1991/92), and will increase to US$40.8 million in the fifth year (1995/96), US$60.7 million in the tenth year (2001/02), and US$86.4 million in the 15th year (2005/06). However, since the production cost is high, the net income after tax will be in deficit over the whole period of economic life, as far as the electricity price is based on the present tariff. If the electricity price could be lowered by 60%, the financial position can be fairly improved so that the project income can gain an operating profit during the whole life except the initial three years, and the accumulated losses can be written off in the seventh year. The financial position will be substantially improved by lowering the electricity price by 80%. In this case, the project will gain an operating profit every year except the initial two years, and the accumulated losses incurred during the initial two years will be written off in the third year.

B. Cash-flow

If the operating losses continue for a few years, the project would encounter difficulties in financial liquidity. Capital intensive projects requiring a large amount of capital investment, like this project, are usually unable to gain an operating profit during the initial two to three years. Nevertheless, if operating losses continue longer than that period, such a project would lose financial soundness due to cash-flow difficulties. If the electricity price is lowered to a level lower than 40% of the present tariff level, the project could be operated with stable cash-flow.

C. Debt service capacity

In view of the debt service coverage ratio analyzed for the project, it is expected that the project will be well capable to sustain debt service capacity, if the electricity price is lowered to a level lower than 40% of the present tariff level.

(4) Profitability of the project

The internal rates of return on investment (financial return rates) of the project have been analyzed on the basis of the projected financial statements. The results of this analysis are summarized below.

	IRR in currrent prices (%)		IRR in constant prices (%)	
Electricity Price	Before tax	After tax	Before tax	After tax
— 80% of the base estimate	3.70	3.06	*	*
— 60% of the base estimate	8.17	6.16	2.23	0.37
— 40% of the base estiamte	11.78	9.38	5.59	3.36
— 20% of the base estimate	14.87	12.24	8.48	6.02
— No value	17.61	14.84	11.03	8.44

Note *: negative returns

Financial profitability of the project appears to be low, and the project therefore will not have sufficient profitability so as to attract investment by the private sector, as well as commercial financing. This project thus could be materialized only by means of HMG/N's public investment as well as financing with concessional loans, and economic benefits rather than financial profitability for the project would be more important criteria for HMG/N's decision making on investment. In this context economic benefits of the project are analyzed. It must be noted, however, that even if the implementation of the project is decided by HMG/N from the national point of view, the project must meet the minimum financial conditions required for sustaining financial liquidity and sound financial structure which is capable of debt service. The premises for satisfying these conditions are:

A. HMG/N's decision on setting the special rate of electricity for the project so that the project can be supplied with electricity priced at lower than 40% of the present tariff level

B. Equity capital more than 20% of the total financing requirement (preferably not less than 30%)

C. Financing with soft-term loans

(5) Economic analysis and socio-economic evaluation

A. Economic return of the project

The primary objective of this project, from the national economic point of view, is to contribute to economic development by means of producing urea fertilizer to substitute for the imports of this fertilizer which the country requires for agricultural development. In the light of this objective, the economic returns of the project have been analyzed in terms of the economic internal rate of return (ERR) and the economic net present value (ENPV). The results of this analysis are summarized below.

- ERR 8.2%
- ENPV US$1.08 million in 1984 constant price terms (at 8% discount rate)

The above analysis uses the economic electricity cost of US¢1.182/kWh in 1984 constant price terms. This economic cost, as stated earlier, has been estimated on the basis of the LRMC assessed for the 1990's, and also by taking into account the assumption that the project will efficiently utilize otherwise unutilized secondary energy, so that the assessment has been made on the basis of reasonably valued economic cost of the energy resource. The analyzed returns reveal that, although the project's economic return seems to be low, without cost penalty exacted from other resources, it could generate a return slightly higher than the opportunity cost for capital resources prevalent in the Kingdom of Nepal, namely 8% per annum. In this context it may be assessed that this project could have economic effects on the national economy to the minimum extent that can barely justify the investment.

B. Effects on foreign exchange savings

The project's effects on foreign exchange savings are analyzed by the following two parameters.

- Net value added ratio, which is the ratio of domestic costs in the production cost, calculated pursuant to the provision of Industrial Enterprises Act in the Kingdom of Nepal

- Net foreign exchange savings, which is calculated as the net total of the foreign exchange savings which may accrue by substitution for the imports of urea fertilizer, after deducting the outlays of foreign exchange which may be incurred for the production of urea fertilizer.

The net value added ratio and net foreign exchange savings estimated for the case where the electricity is supplied at a rate set as 40% of the present tariff level, shows 54% of annual production cost (average in 15 years) for the former and US$560.75 million for 15 years (averaged at US$37.38 million per annum) in current price terms. If the electricity price for the project is as low as 40% of the present tariff rate, the production cost will be lower than the import prices except for the initial three years. On the other hand, the foreign exchange cost will always be lower than the import prices. These figures indicate that the project could contribute to foreign exchange savings.

C. Other economic benefits

Since the requirements for urea fertilizer are met by imports, the supply of this fertilizer has been often short due to difficulties in timely procurement of the required quantities, and this shortage has impeded agricultural production. This project could contribute to the country's agricultural development, since the domestic production could ensure the timely supply of urea fertilizer as required.

In addition to the contribution to the country's agriculture, this project would also contribute to the creation of employment opportunities, by permanent direct employment of about 300 persons and indirect employment of 100 persons who would be directly or indirectly engaged in the plant operation, in addition to the employment of about 1,000 persons for plant construction. Further, the project would have external effects on relevant industries and regional development. If those indirect benefits are taken into account, the economic returns of the project may be larger than the quantitatively assessed returns, and therefore it may be assessed that the project would be economically feasible.

Chapter 3 CONCLUSION AND RECOMMENDATIONS

3-1 Conclusion

(1) Marketability of urea fertilizer

In view of farmers' practices in using urea fertilizer and its suitability for agriculture in Nepal, it is likely that this fertilizer will come to have a dominant share in Nepal's nitrogen fertilizer consumption, and its domestic demand will reach approximately 51,000 tons in 1991/92 and 70,000 tons in 2000/01, so that in and after 1991/92 the country's urea fertilizer markets will have a sufficient scale to absorb the output of an urea fertilizer plant having production capacity of 250 to 300 TPD. The Agricultural Inputs Corporation (AIC), a state-owned corporation, is the sole agency for marketing and distribution of fertilizer in Nepal. This arrangement is expected to continue in the future. When a urea fertilizer plant is established in Nepal, all of the output from the plant will be taken by AIC. As AIC has organized a network and facilities for fertilizer distribution throughout the country, they will be capable to undertake the marketing and distribution of the urea fertilizer to be produced.

(2) Technical feasibility of the project

For defining the project scheme for a urea fertilizer plant, the primary importance is assigned to selection of the processes for manufacturing ammonia and carbon dioxide which are intermediate materials for manufacturing urea fertilizer. The ammonia manufacturing process varies depending upon the hydrogen source used. As water and electricity are indigenous resources available in Nepal, this project will adopt a process which manufactures ammonia by synthesis of hydrogen generated by electrolysis of water, with nitrogen obtained by air fractionation. For carbon dioxide, the most economical source in Nepal is to recover this from cement plant flue gas. Adoption of these processes is technically feasible, since the process for generating hydrogen by electrolysis of water is commercially proven, and the principal process technology for recovering carbon dioxide from cement plant flue gas has been established for commercial application. The processes for obtaining nitrogen by air fractionation, ammonia synthsis, as well as urea manufacturing are all commercially proven. Nevertheless, the assurance of reliable supply of electricity and cement plant flue gas is a prerequisite for planning the urea fertilizer plant based on those process technologies and ensuring long term stable operation of the plant.

A. Availability of electricity

In the near future, following the completion of Kulekhani No. 2 hydropower plant (32 MW) and Andikhola hydropower plant (5 MW) which now are under construction, the construction of Marsyangdi hydropower plant (66 MW) will be started. It is likely that, with the completion of the Marsyangdi project, Nepal's electricity supply will have a surplus over domestic demand to some extent for one to two years after 1988/89, but thereafter the supply condition will again be tight.

HMG/N has a plan to carry out the Sapta Gandaki hydropower project (225 MW), after the Marsyangdi project. The Sapta Gandaki project consists of three stages of construction, in which the first stage is to be completed in 1991/92. If this project is completed as now planned, Nepal will have a large surplus supply of energy except for two to three months in the dry season when the electricity supply/demand used to be tight, as well as at the daily peak time (four to five hours in morning and evening), so that electricity generated by this surplus energy will be available for the urea fertilizer plant. Hence it is foreseen that, if the Sapta Gandaki project is implemented, and each stage of the construction is completed as per the schedule particularly with regard to the completion of the first stage in 1991/92, at least for five years starting in that year, there will be assurance that there will be adequate electricity supply to operate a urea fertilizer plant having a capacity up to 300 TPD with annual capacity utilization averaging 83% of full capacity based on 330 on-stream days per annum.

At present the availability of electricity for the years beyond that period can not be foreseen, because there are no definite plans for the implementation of hydropower projects to be developed following the Sapta Gandaki. Nevertheless Nepal has great potential for hydropower developments. Basic studies and investigation for the development of hydropower projects following the Sapta Gandaki project are underway. If those projects are implemented in time as per the master plan, Nepal may have surplus energy capacity available for use at the urea fertilizer plant in the rainy season as well as daily off-peak time so that the plant can be operated by efficient utilization of surplus energy without burdening peak load, because the envisaged hydropower projects will have installed capacity exceeding 200 MW.

In actuality, however, the assurance that the Sapta Gandaki project and subsequent projects will be implemented in time must be assumed as prerequisites to ensure the long term stable supply of electricity for the urea fertilizer plant. This study has examined the planning of the urea fertilizer plant, on the assumption that the first stage of Sapta Gandaki project will be completed in 1991/92 as per targeted schedule. It must be emphasized, however, that, prior to the decision on implementation of this project HMG/H should carefully investigate the timing of the development of future hydropower projects including the Sapta Gandaki project, and set the schedule for this project to meet the development of those hydropower projects in future.

B. Availability of cement plant flue gas

The existing cement plant is that of the Himal Cement Co., (PVT) Ltd. (HCC) located at Chobar, Kathmandu, the capacity of which is 160 TPD of clinker. Another plant is being constructed at Hetauda by Hetauda Cement Industries, Ltd. (HCI). This plant will be completed by the end of 1984, and will have the capacity of 750 TPD of clinker. Supply conditions of flue gas were investigated for both plants. As the result, it is judged that flue gas from the HCI's plant is more suitable for recovering carbon dioxide, since this plant adopts a modern process. The quantity of the flue gas available from this plant is also adequate. Hence it is judged that the flue gas from the HCI's plant is adequate as the source for carbon dioxide to be supplied to the urea fertilizer plant.

As the urea fertilizer plant will use the HCI's cement plant flue gas, the plant will have to be located adjacent to that in Hetauda. When compared with the site area adjacent to the HCC's cement plant at Chobar, Kathmandu, the site conditions of the area near HCI, Hetauda are superior to those of HCC, Kathmandu.

As the conclusion of this study, the following project concept is proposed.

A. Establish a 275 TPD urea fertilizer plant which is to be located adjacent to the HCI's cement plant site in Hetauda, and

B. Set the completion target for the urea fertilizer plant as 1991/92 to meet the schedule set for the Sapta Gandaki project.

It must be noted, however, that the HMG/N's assurance on the long term stable supply of electricity is assumed as an essential condition for this proposal. Therefore it is recommended that, prior to the decision on the implementation of the project, HMG/N should carefully investigate this aspect. If HMG/N determines that this condition will be satisfied, the project is judged to have satisfactory conditions to be technically feasible.

(3) Financial viability of the project and its economic effects

If a 6% annual escalation of electricity price is assumed, it is judged that, if the present tariff pricing at U$C 3.56/kWh is applied to the electiricity supplied to the urea fertilizer plant, this project would not be financially viable, because the production cost of the project seems to be far higher than the price of imported urea in future. If it is possible to set a concessional rate for the project at a price level lower than 40% of the present tariff price, however, the project may be marginally able to sustain a financially viable structure. Even in such an event, this project will not be attractive to private sector investors or commercial financing sources, because financial profitability of the project would be low.

The economic return of the project is assessed as 8.2%, which is below the common standard of an acceptable return rate. However, this project may be able to gain returns slightly more than the opportunity cost for capital resource prevalent in the Kingdom of Nepal (8% per annum), and therefore the project is expected to attain the minimum of economic returns, although by a small margin, as required for a favorable investment decision on the project. At the same time, it is expected that the project could contribute to foreign exchange savings of the country, while contributing to agricultural development by means of assuring stable supply of urea fertilizer, as well as increases in employment and other effects on the economic development of the country. In view of these effects, it is assessed that the project is likely to be economically feasible, although by a small margin.

It must be noted, however, that the setting of a concessional rate of electricity for the project, as recommended earlier, is essential for the project to be financially viable. As this project is so conceived as to maximize efficient utilization of unutilized secondary energy without burdening the peak load, the consumption of electricity by the project would not cause any increase in electricity supply costs, but it would rather contribute to reduce the costs by improving average load. Hence even if electricity is supplied at a concessional rate specially set for the project, it would result in increases in net operating income of NEC, rather than causing a financial burden.

(4) Overall evaluation

Summing up the foregoing discussions, the following two conditions are esssential for this project.

A. Assurance of HMG/N on the definite implementation of the Sapta Gandaki project and subsequent hydropower projects at times beneficial to the urea fertilizer project

B. Setting of a concessional rate for electricity to be supplied for the project, at a level lower than 40% of the present tariff rate

The overall evaluation of the project leads to the conclusion that, if the above conditions are adopted, the project will satisfy by a small margin the minimum requirements to justify the investment as being appropriate from the national economic point of view.

3-2 Recommendations

(1) Among several conditions, in particular assurance of the long term stable supply of electricity is a prerequisite for this project to be technically feasible. It is recommended that, prior to the final decision on this project, the possibility on the timely implementation of the Sapta Gandaki project and subsequent hydropower projects be ensured by the HMG/N.

(2) Reducing electricity cost is essential for the project to be financially viable. It is recommended that the HMG/N consider to set a concessional rate of electricity for the project at a level lower than 40% of the present tariff rate.

(3) Since the HCI's cement plant in Hetauda is still under construction, at present there are no data showing actual analysis of flue gas composition. It is recommended to conduct the measurement and analysis of the flue gas when the plant starts operation so that the actual composition can be confirmed for refinement of the basic design of the carbon dioxide removal plant in the urea fertilizer plant.

(4) It is recommended that, when the HMG/N's decision has been made to implement the project, immediate steps be taken to organize an executing entity for the project, as well as a project team consisting of experienced engineers and staff in Nepal and assisted by qualified foreign consultants so that the project can be launched for implementation under a responsible organization. This organization should have authority and responsibility to coordinate with the management of the HCI's cement plant which will supply flue gas to the urea fertilizer plant so that arrangements for optimum operation can be made for both the cement plant and the urea fertilizer plant.

Table 1 PAST TREND OF FERTILIZER CONSUMPTION IN NEPAL

(Unit: Nutrient ton)

Year	N	P_2O_5	K_2O	Total
1965/66	342	90	12	444
1966/67	1,070	276	104	1,450
1967/68	1,839	728	167	2,734
1968/69	2,382	659	159	3,200
1969/70	3,380	1,049	156	4,585
1970/71	4,111	1,081	214	5,406
1971/72	5,554	1,952	462	7,968
1972/73	7,698	3,150	1,052	11,900
1973/74	9,003	3,167	918	13,088
1974/75	8,923	2,849	886	12,658
1975/76	8,423	2,491	1,352	12,266
1976/77	10,696	2,780	1,422	14,898
1977/78	13,013	3,383	1,079	17,475
1978/79	14,115	3,692	1,456	19,263
1979/80	14,480	4,277	1,178	19,935
1980/81	16,984	4,993	587	22,564
1981/82	17,976	5,003	771	23,750
1982/83	22,896	7,167	912	30,975

Source: AIC

Table 2 PAST TREND OF NITROGEN FERTILIZER CONSUMPTION BY TYPE IN NEPAL

(Unit: N ton)

	1965-69 Average	1970-74 Average	1975-79 Average	1980-82 Average
Urea	93 (5.1)	2,140 (30.3)	7,556 (61.1)	12,751 (66.1)
Ammonium sulphate	1,215 (67.4)	2,920 (41.4)	1,577 (12.7)	900 (4.7)
Di Ammonium Phosphate	- (-)	- (-)	- (-)	106 (0.6)
CX (20-20-0)	457 (25.4)	1,959 (27.7)	2,295 (18.8)	5,119 (26.6)
CX (23-23-0)	12 (0.7)	30 (0.4)	166 (1.3)	276 (1.4)
CX (15-15-15)	0 (0.0)	12 (0.2)	754 (6.1)	124 (0.6)
CX (5-6-7)	- (-)	- (-)	2 (0.0)	2 (0.0)
Other N	26 (1.4)	4 (0.0)	0 (0.0)	2 (0.0)
Total N	1,803 (100.0)	7,065 (100.0)	12,350 (100.0)	19,280 (100.0)

Note: Figures in the parentheses mean the percent of total N.

Source: AIC

Table 3 AGRICULTURAL PRODUCTION IN NEPAL

(Unit: ton)

	1971/72				1982/83			
	High Hill	Hill	Terai	Kathmandu Valley	High Hill	Hill	Terai	Kathmandu Valley
Paddy	43,933	344,876	1,851,385	103,632	44,330	390,680	1,297,430	100,180
Maize	76,586	402,678	225,328	54,134	56,730	358,920	227,280	75,310
Wheat	29,621	58,638	99,502	35,433	16,980	145,050	444,460	50,140
Millet	17,654	87,669	17,291	6,886	16,110	87,100	17,840	3,820
Sugarcane	1,042	27,712	212,493	3,573	650	41,180	574,740	-
Jute	-	2,287	55,752	20	N.A.	N.A.	N.A.	N.A.
Oilseed	671	11,766	44,008	1,000	520	13,210	55,750	400
Tobacco	80	367	6,458	-	-	160	6,480	-
Potato	52,658	127,465	89,383	23,862	77,830	190,620	104,520	28,210

Note: N.A. = Not avairable

Source: Dept. of Food & Agricultural Marketing Series, Nepal

Table 4 PROJECTED DEMAND FOR NITROGEN FERTILIZER IN NEPAL

(Unit: ton)

Region	1982 (Actual)	1985	1990	1995	2000
Eastern Dev. Region	1,372	1,721	2,404	2,476	2,511
High Hill	55	54	67	81	95
Hill	354	285	447	466	474
Terai	963	1,382	1,890	1,929	1,942
Central Dev. Region	15,702	16,825	19,751	23,805	15,383
High Hill	864	925	957	963	967
Hill	1,987	2,162	2,446	2,706	2,716
Kathmandu Valley	6,234	6,743	7,591	9,597	8,971
Terai	6,617	6,995	8,757	10,539	11,700
Western Dev. Region	2,787	3,051	3;974	4,661	4,941
High Hill	16	30	24	18	17
Hill	888	890	1,113	1,339	1,548
Terai	1,883	2,131	2,837	3,304	3,376
Mid-Western Dev. Region	777	597	870	887	1,064
High Hill	5	10	10	10	9
Hill	115	93	189	193	195
Terai	657	494	671	684	860
Far-Western Dev. Region	286	295	321	498	513
High Hill	15	9	9	18	17
Hill	18	45	47	47	48
Terai	253	241	265	433	448
Total	20,924	22,489	27,320	32,327	33,383
High Hill	955	1,028	1,067	1,090	1,105
HIll	3,362	3,475	4,242	4,751	4,981
Kathmandu Valley	6,234	6,743	7,591	9,597	8,971
Terai	10,373	11,243	14,420	16,889	18,326

Table 5 EXPECTED SALES VOLUME OF UREA

(Unit: ton)

	Total Demand for Nitrogen Fertilizer		Expected Ureas' Share of Total Nitrogen Demand	Maximum Expected Sales Volume of Urea*/
	N ton	As Urea		
1985	22,500	48,900	72.5%	35,500
1990	27,300	59,300	75.0%	44,500
1995	32,300	70,200	90.0%	63,200
2000	33,400	72,600	95.0%	69,000

Note: */ Yearly change in the "maximum expected sales volume of urea" is as follows.

1990	44,500
1991	48,800
1992	52,600
1993	56,400
1994	60,100
1995	63,200
1996	64,700
1997	65,900
1998	67,100
1999	68,100
2000	69,000

Table 6 PROJECTION OF UREA PRICE

(Unit: US$/ton - Constant Prices at 1984)

	1983 (Estimated)	1985	1990	1995	2000
CIF Calcutta (Bagged), (A)	192	225	255	269	279
Cost up to retailers, (B)	93	93	93	93	93
Total import costs, (A+B) (ex-retailers)	285	313	348	362	372
Transportation cost from the project site to the market, (C)	9	9	9	9	9
Retailer mark-up (D)	16	18	20	21	21
Ex-factory price, (A+B) - (C+D)	260	286	319	332	342

Note: 1/ Based on the projected price in Table 2-6.

(CIF calcutta, bagged price) = (FOB US Gulf, bulk price) + (Freight form US Gulf) + (Bag/Bagging costs)

Freight rate from US Gulf = US$35/ton

Bag/Bagging costs = US$20/ton

Table 7 ESCALATED CAPITAL COST ESTIMATE

NEPAL UREA PROJECT (275 TPD)

(Unit: US$MIL.)

	BASE PROJECT COST		PHYSICAL CONTINGENCY		PRICE CONTINGENCY		TOTAL PROJECT COST (AS COMPLETED)		
	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	TOTAL
A. LAND ACQUISITION	0.0	0.59	0.0	0.03	0.0	0.10	0.0	0.72	0.72
B. SITE PREPARATION	1.35	0.15	0.07	0.01	0.18	0.04	1.60	0.20	1.80
C. PLANT DIRECT COST									
C-1 PROCESS UNITS	38.41	1.01	1.92	0.09	7.86	0.67	48.19	2.57	50.76
C-2 UTILITY FACILITIES	10.17	0.53	0.51	0.03	2.04	0.19	12.72	0.75	13.47
C-3 AUXILIARY FACILITIES	1.94	0.82	0.10	0.04	0.38	0.29	2.42	1.15	3.57
C-4 OFFSITE FACILITIES	1.70	2.31	0.09	0.12	0.32	0.79	2.11	3.22	5.33
D. SPAREPARTS, CATL. & CHEM.	2.33	0.0	0.12	0.0	0.59	0.0	3.04	0.0	3.04
E. CONST. & ERECTION LABOR	9.87	3.44	0.49	0.17	2.23	1.42	12.59	5.03	17.62
F. CONST. EQUIPMENT	7.82	0.0	0.39	0.0	1.38	0.0	9.59	0.0	9.59
G. TRANSPORT, INSURANCE & DUTY	2.00	2.59	0.10	0.13	0.40	0.94	2.50	3.66	6.16
H. INDIRECT FIELD EXPENCES	0.33	0.49	0.02	0.02	0.07	0.20	0.42	0.71	1.13
I. ENGINEERING SERVICES	9.31	0.85	0.47	0.04	1.80	0.30	11.58	1.19	12.77
J. PROJECT MANAGEMENT SERVICES	2.45	0.37	0.12	0.02	0.48	0.13	3.05	0.52	3.57
K. PRE-OPERATION EXPENSES	0.29	1.90	0.01	0.10	0.08	0.92	0.38	2.92	3.30
L. BASE PROJECT COST	87.97	15.85	4.41	0.80	17.81	5.99	110.19	22.64	132.83
M. INITIAL WORKING CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.40	2.28	2.68
N. INTEREST DURING CONSTRUCTION	0.0	0.0	0.0	0.0	0.0	0.0	9.28	0.0	9.28
O. TOTAL FINANCING REQUIRED	87.97	15.05	4.41	0.80	17.81	5.99	119.87	24.92	144.79

Table 8 PROJECTED UREA PRODUCTION COST BY CHANGES IN ELECTRICITY PRICE
(Capacity 275 TPD: Bagged Urea)

(Unit: US$/ton)

Year	Base Estimate		20% Reduction		40% Reduction		60% Reduction		80% Reduction		100% Reduction	
	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price	Current Price	1984 Const. Price
1991/92	836.0	556.0	764.9	508.7	693.9	461.5	622.8	414.2	551.7	366.9	480.7	319.7
1992/93	848.2	532.2	772.8	484.9	697.5	437.6	622.2	390.4	546.8	343.1	471.5	295.8
1993/94	839.7	497.0	759.8	449.7	680.0	402.5	600.0	355.1	520.3	308.0	440.4	260.7
1994/95	842.1	470.2	757.4	422.9	672.8	375.7	588.1	328.4	503.5	281.2	418.8	233.9
1995/96	854.3	450.0	764.6	402.8	674.0	355.5	585.1	308.2	495.4	261.0	405.7	213.7
1996/97	871.8	433.3	776.7	386.0	681.6	338.7	586.5	291.5	491.4	244.2	396.3	196.9
1997/98	894.9	419.6	794.1	372.3	693.2	325.0	592.4	277.7	491.6	230.5	390.8	183.2
1998/99	920.4	407.1	813.5	359.8	706.6	312.5	599.8	265.3	492.9	218.0	386.1	170.8
1999/2000	948.9	395.9	835.6	348.7	722.3	301.4	609.0	254.1	495.8	206.9	382.5	159.6
2000/01	980.5	386.0	860.4	338.7	740.3	291.4	620.3	244.2	500.2	196.9	380.2	149.7
2001/02	838.9	311.5	711.7	264.3	584.4	217.0	457.1	169.8	329.8	122.5	202.6	75.2
2002/03	881.0	308.7	746.1	261.4	611.2	214.1	476.2	166.8	341.3	119.6	206.4	72.3
2003/04	925.9	306.0	782.9	258.8	639.8	211.5	496.8	164.2	353.8	116.9	210.8	69.7
2004/05	974.0	303.7	822.4	256.4	670.8	209.2	519.2	161.9	367.6	114.6	216.1	67.4
2005/06	1,025.6	301.7	864.9	254.4	704.2	207.1	543.5	159.9	382.8	112.6	222.2	65.4
Average (1991/92 - 2005/06)	898.8	405.3	788.5	358.0	678.2	310.7	567.9	263.4	457.7	216.2	347.4	168.9

Notes: 1/ Excluding interest for short-term loan which will be borrowed for recovering cash deficit incurred due to financial losses
2/ Using deflater of 6% p.a. for calculating the production cost in 1984 constant prices

Figure 1 FERTILIZER CONSUMPTION TREND IN NEPAL

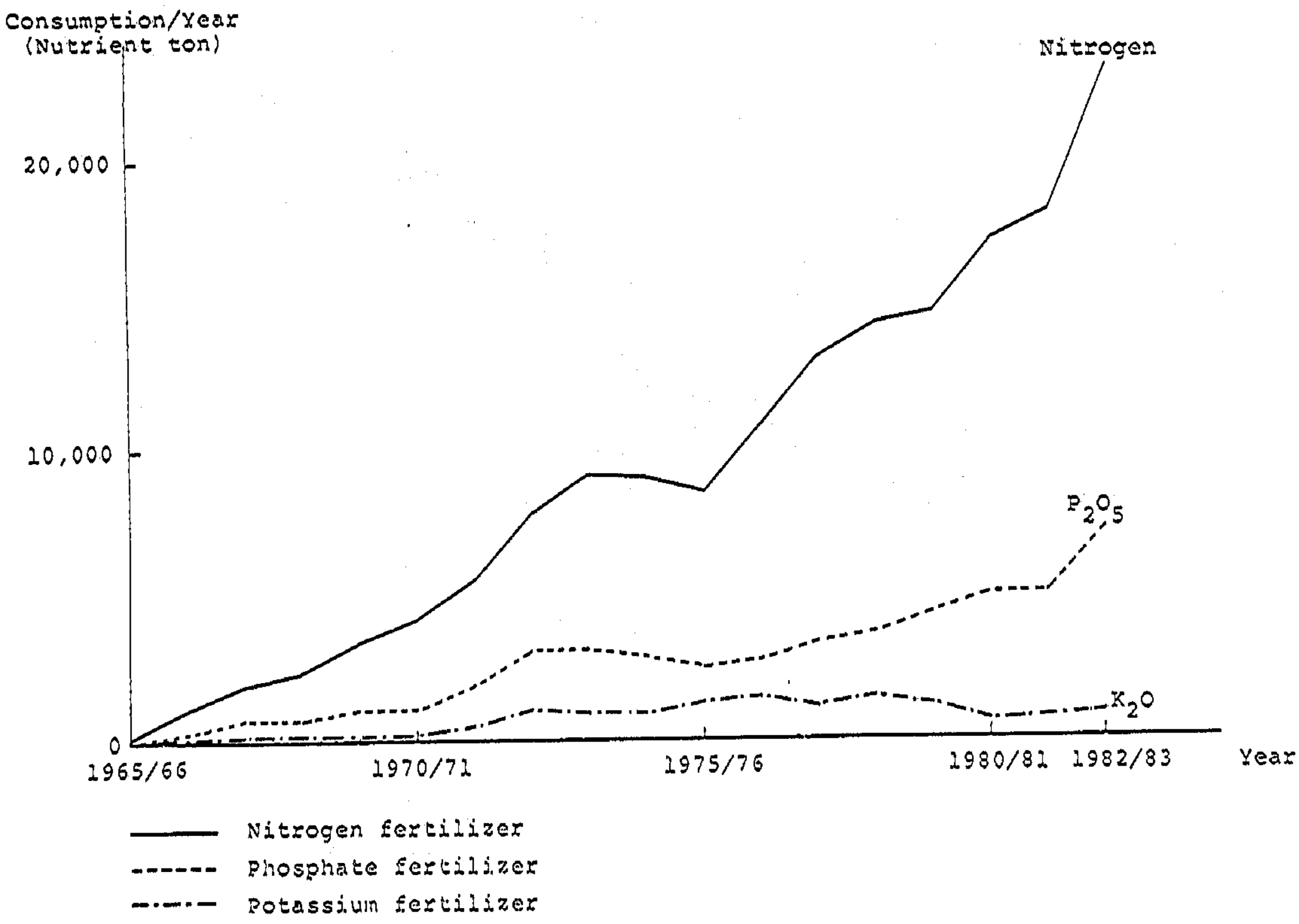


Figure 2 PAST TREND AND PROJECTION OF NITROGEN FERTILIZER CONSUMPTION IN NEPAL

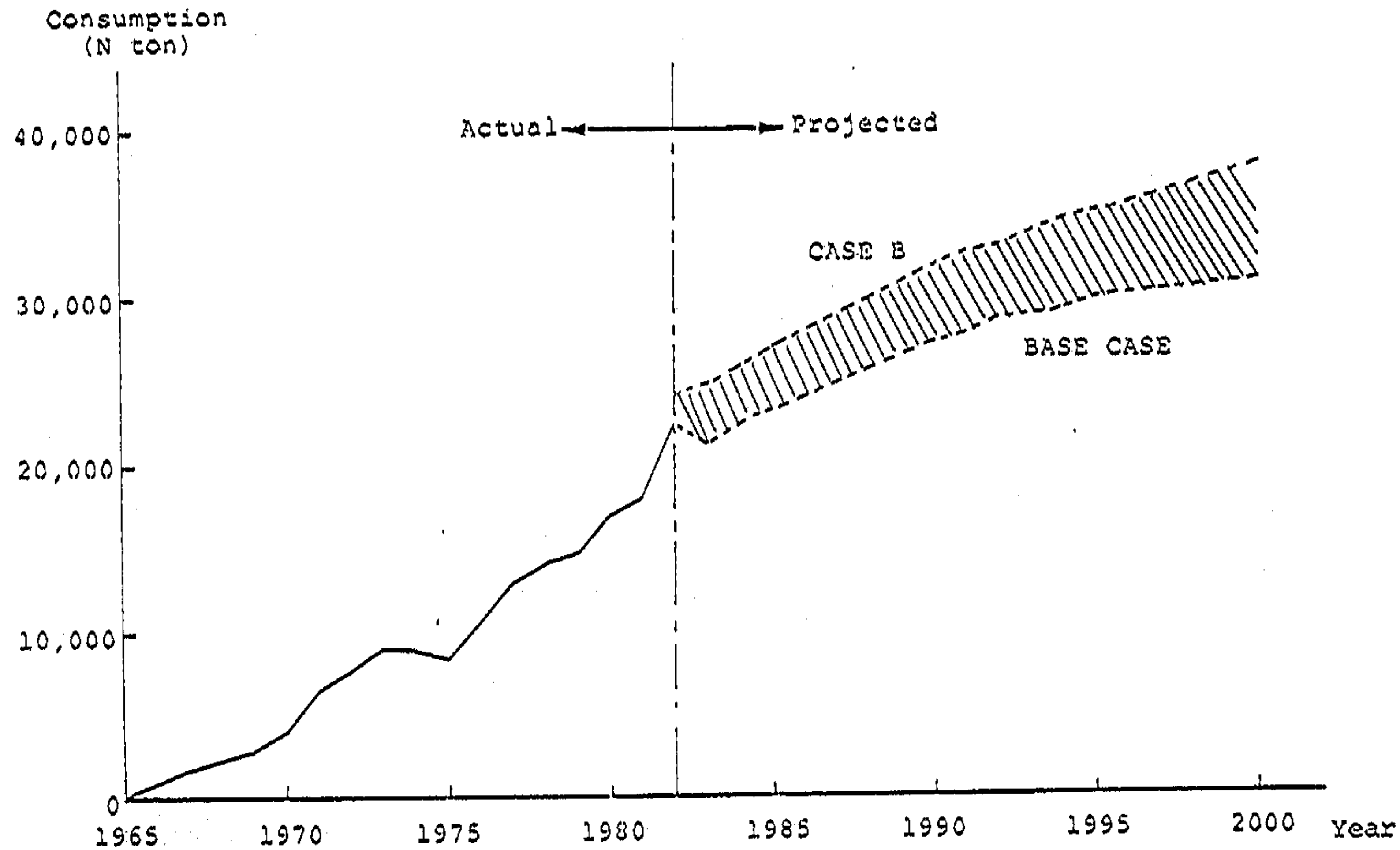
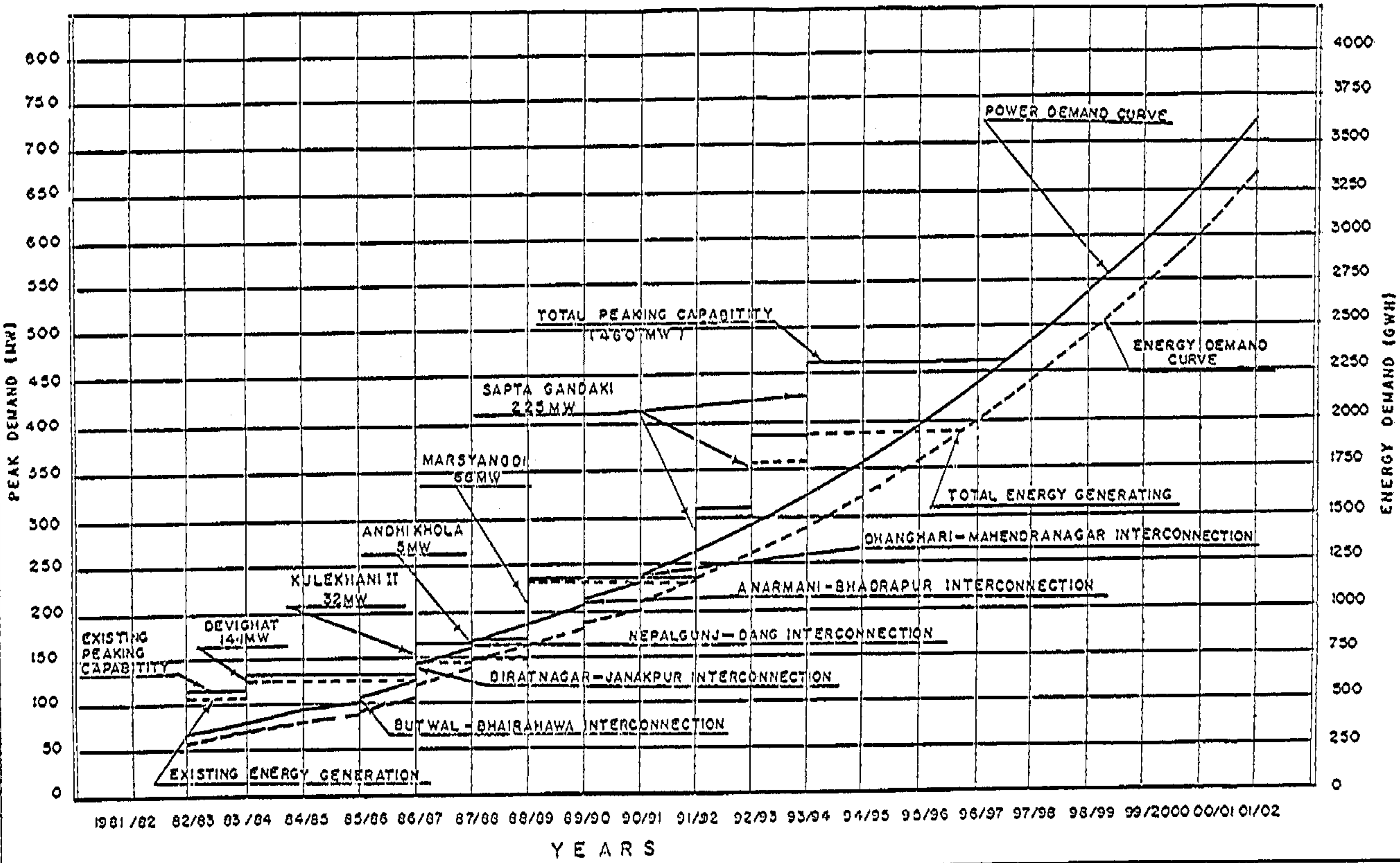


Figure 3 NEPAL POWER SYSTEM INTEGRATED DEMAND AND GENERATION EXPANSION



Part I INTRODUCTION

Chapter 1 Objectives and Scope of the Study

Chapter 2 Brief of the Performance, and Outline of the Study

Chapter 3 Economic Background of the Project

Part I INTRODUCTION

Chapter 1 Objectives and Scope of the Study

1-1 Background and objectives

His Majesty's Government of Nepal (HMG/N) envisages to establish a urea fertilizer plant, the first one for manufacturing chemical fertilizer in the Kingdom of Nepal. The economy of Nepal largely depends on agriculture. The agriculture sector currently contributes about 60% of the Gross Domestic Product (GDP) and about 90% of employment in the country. Urea fertilizer is one of agricultural inputs requisired for increasing yields. In recent years urea fertilizer has had a dominant share in the country's nitrogen fertilizer consumption, although the requirements for this fertilizer have had to be met by imports. HMG/N is interested in promoting the domestic production of urea for import substitution, because ammonia, an intermediate for urea, can be produced from hydrogen obtained by electrolysis of water that utilizing only indigenous resources — water and hydropower.

With this background, HMG/N has requested the Government of Japan to provide technical assistance for conducting a feasibility study on the establishment of a urea fertilizer plant in the Kingdom of Nepal, under the technical cooperation programs of the Government. In response to this request the Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs, dispatched a preliminary study mission to the Kingdom of Nepal in October, 1983. As a result, an agreement was made on the 4th of October, 1983 between JICA and the Ministry of Industry, HMG/N, setting forth the Scope of Work for the feasibility study. This study thus has been carried out in accordance with the agreed Scope of Work, a copy of which is attached as Annex I-1 in this report.

1-2 Scope of the study

The scope of the study set forth in that agreement broadly consists of the following aspects:

(1) Study on the background of the project
(2) Study of urea fertilizer markets in the Kingdom of Nepal
(3) Study on raw materials required for manufacturing urea fertilizer
(4) Investigation of alternative plant sites
(5) Examination and formulation of development planning of the urea fertilizer plant, and conceptional design for the required plants and facilities
(6) Study of necessary measures for environmental control
(7) Financial projections and analysis of the project
(8) Socio-economic evaluation of the project
(9) Conclusion of the study, and recommendations derived therefrom

Chapter 2 Brief of the Performance, and Outline of the Study

2-1 Manner and schedule

In the course of the study a JICA study team (The Study Team) led by Mr. Masayasu SAKANASHI and consisting of six other experts*1 visited the Kingdom of Nepal for field surveys lasting 21 days beginning January 9, 1984. This study was made by precise and thorough investigation and examination of the findings, data and information obtained through the field surveys. Following the accomplishment of the field surveys in Nepal, two experts of the Team's members visited India to conduct surveys on port and transport conditions in Calcutta where imported equipment and materials for the plant would be unloaded. To assist the Study Team in the field surveys, counterparts (The Counterparts)*2 were assigned from among staff members of the Industrial Services Centre, an institution organized under the jurisdiction of the Ministry of Industry, HMG/N. During the field surveys, the Study Team, with the Counterparts' assistance, carried out collection and analysis of necessary data and information, investigation of the candidate plant sites, as well as on-the-spot surveys on fertilizer markets and relevant industries in the country. A record of the activities performed, as well as a list of the offices visited by the Study Team in the field surveys are attached as Annex I-3, and a list of data and information collected is attached as Annex I-4.

2-2 Outline of the study

In light of the scope of this study stated in 1-2 of this Part, the main areas to be studied may be classified as follows:

(1) Market study

(2) Examination of technical aspects of development planning of the urea fertilizer plant

(3) Financial projections and analysis, and socio-economic evaluation of the project

The outline of studies made of each of these areas is described below:

(1) Market study

The market study was made by giving primary attention to (a) analyzing the present situation of agriculture and fertilizer consumption in the Kingdom of Nepal, and (b) forecasting the outlook of future demand for urea fertilizer and possible sales of this fertilizer which is the product from this project. In the meanwhile, studies were made on the systems in use for the marketing and distribution of fertilizer and also on underlying constraints for fertilizer movement in the country, and based on those studies examinations were made of efficient systems and facilities which are required for the project or are needed for successful operation of the marketing and distribution of urea fertilizer produced at the plant.

(Notes) *1: Names of the Team's members who visited the Kingdom of Nepal for the field surveys are listed in Annex I-2.
*2: Names of the counterparts are also listed in Annex I-2.

In addition to the above, the Study Team attempted to predict the future tendency of international markets, as well as international prices, for urea, which were used as a basis for the financial and economic evaluation of the project. The outcome of these studies is described in Part II and Annex II of this report.

(2) Examination of technical aspects of development planning of the urea fertilizer plant

Ammonia and carbon dioxide are intermediates for manufacturing urea fertilizer. This project in conceived so as to use ammonia produced from hydrogen which is to be obtained by electrolysis of water, while using carbon dioxide recovered from cement plant flue gas. Hence a stable supply of electric power and adequacy of flue gas available from a cement plant are fundamental requirements to be satisfied for assuring feasibility of the project. In this context primary attention was given to (a) the outlook for the country's electric power supply in the future and (b) investigation of adequacy in quality and quantity of flue gas available at two cement plants, one being operated by Himal Cement Co. and the other being constructed at Hetauda and owned by Hetauda Cement Industries Co.

As cement plant flue gas is the supply source for carbon dioxide, the site for the urea fertilizer plant should be adjacent to a cement plant. Investigation was made on site conditions in those two plant vicinities to select the best alternative. Further, relevant industries, local legislation and a wide range of other aspects were studied, while road and transport conditions in the country were carefully investigated by paying particular attention to the need to transport heavy equipment.

Based on those studies and investigations, examinations were made to develop the optimum plan for the project and draw up conceptional designs for the plants and facilities required. Further, examinations were also made to formulate an efficient plan for the implementation and management of the project so as to meet the conditions prevailing in the country. The outcome of those studies, investigations and examinations is described in Part III and Annex III of this report.

(3) Financial projections and analysis, and socio-economic evaluation of the project

The financial projections and analysis, and socio-economic evaluation of the project, were made in the following steps.

A. Estimates of total financing requirement, and formulation of financing plan
B. Production cost estimates, and financial projections and analysis
C. Socio-economic analysis
D. Overall evaluation of the project

The first step (A) was to estimate the total financing requirement for the project, and formulate an optimum plan for financing the estimated requirement. In step (B), production cost estimates, and financial projections and analysis, were made for the project by using the estimated total financing requirement and other factors assumed for the projections. Step (C) carried out quantitative and qualitative assessment of economic benefits and impacts which the project would have. In step (D) the above analyses and assessment were integrated for overall evaluation on financial viability and soundness, as well as economic feasibility of the project.

In order to discuss the issue of electric power price, assessment was made of the price structure, including efforts to assess the economic cost of electric power. Further, another analysis was made on possible affects to the financial viability and economic feasibility of the project which are attributable to electric power cost. The outcome of those analyses and assessment is described in Part IV and Annex IV of this report.

Chapter 3 Economic Background of the Project

3-1 Economic conditions of the Kingdom of Nepal

3-1-1 General conditions and geographic characteristics

The Kingdom of Nepal, having an area of 147,181 sq. km., lies between longitudes 8014' to 88112' East and latitudes 26122' to 30127' North. The country, shaped like an irregular rectangle varying from 144 km. to 240 km. in width, is a landlocked country, where the Himalayan range forms the northern border touching Tibet of the People's Republic of China and all the other sides border India. The map showing geography of the country in presented at the top of this report.

The country comprises three natural regions as follows:

A. Terai Region

This region consists of the foothills and fertile plains sloping southwards, and covers 35,810 sq. km. or nearly one fourth of the country. The foothills gently rise to 600 meters and then steeply to 1,200 meters.

B. Middle Region (or Hill Region)

The Middle Region is the ranges which constitute a broad complex of hills and valleys, and provides an area much eroded by a large network of streams and rivers. Kathmandu and Pokhara are the main valleys located along these ranges.

C. Trans-Himalayan Region (or Mountain Region)

It is an elevated area rising over 4,550 meters, and has the highest mountain ranges in the world.

Nepal has three large rivers which flow mostly from north to south and flow into the major rivers of the Indian subcontinent, namely the Indus, the Ganges, and the Brahmaputra.

The country is broadly divided into four climatic zones.

A. Sub-tropical Monsoon Climate

The areas in this zone are Churia Hills, Inner Terai and areas up to 1,200 meters. Temperatures rise over 38°C in summer in some parts. 90 percent of rainfall is in summer and the rainfall varies from 200 cm per annum in the East to 125 cm in Central Nepal and 100 cm in the West. In winter, climates are mild with dry weather.

B. Temperate Monsoon Climate

The areas in this zone are those lying between 1,200 meters to 2,130 meters. Warm summer and cool winter climates prevail. The average temperature varies from 27°C to 41°C, and annual rainfalls average 150 cm.

C. Cold Temperate Climate

Areas between 2,130 meters and 3,700 meters fall within this zone. Climates are mild in summer (temperature about 21°C) and in winter it is very cold (temperature about 1°C) with occasional snowfall.

D. Alpine Climate

This climate is prevalent in the Himalayan region. Temperatures are low throughout the year.

The geographic and topographic conditions as stated above are constraints for foreign trade, as well as local distribution and transport, thereby restraining economic growth of the country. Rapid population growth has been experienced in the last 10 years. Table 1-1 shows regional distribution of the population in 1971, 1976 and 1981. The population increased from 11.56 million in 1971 to 15.02 million in 1981 at a growth rate of 2.7% per annum. The majority of Nepal's population resides in the Hills. Most of inhabitants residing in the Hills, except the main valleys like Kathmandu and Pokhara, suffer from insufficient food supply and low incomes because of unfavorable conditions for cultivation and constraints for inter-regional trade there. The Terai region is favored by comparatively good conditions for cultivation. Constraints for transportation, however, limit the supply of foodgrains from this region to the Mountain and Hill regions.

3-1-2 Economic structure

Table 1-2 gives current records of the Gross Domestic Product (GDP) in the Kingdom of Nepal. As is cited for 1981/82 GDP, the agricultural sector accounts for a majority (59%), followed by the construction sector (9%), finance, insurance and real estate (8%), services (8%), and transport and communications (7%), while the manufacturing sector accounts for only 4%, followed by trade and restaurants, including hotels (4%), and electricity, gas and water (1%). This reveals that the economy of Nepal is largely dependent on the agriculture and the performance of this sector therefore has substantial effect on the nation's economy.

Table 1-3 shows the balance of payments in the Kingdom of Nepal. Nepal's balance of payments has been characterized by wide trade deficits. The current account has been in increasing deficit every year. This deficit has traditionally been matched by inflows of official grants and concessional loans, leading to a surplus in the overall balance of payments. In 1982/83, however, the overall balance of payments shifted to become a deficit.

Table 1-4 gives the National Accounts. The total expenditures have always exceeded the GDP, and majority of the expenditures has been for consumption. The investment and the domestic saving items account only for 15 to 16% and 11% of GDP every year. The economic structure of Nepal as briefly described above is obliged to be heavily dependent on official grants and aid financing for development expenditures.

Table 1-5 shows composition of the country's foreign trades. Agricultural products or primarily processed agricultural products comprise the majority of exports, whereas imports are monthly manufactured products and capital goods. Trade with India accounts for a large share in the Nepal's foreign trade — about 60% of total exports and about 50% of total imports.

3-1-3 Economic development plan

The Sixth Five Year Plan (1980/81 - 1984/85) was launched in 1980/81. The preceding Plan period (1975/76 - 1979/80) has resulted in stagnant economic growth which averaged 2.1% per annum against the Plan's target of 5% per annum. This is attributed mainly to three poor monsoons which caused poor productivity of agriculture, and especially of foodgrains. Though the Fifth Five Year Plan has set the target for increases in agricultural production of 19.2% with 17% for foodgrains and 68% for cash crops, all of these sectors, especially the foodgrain sector, have recorded poor performance.

Under such conditions, the Sixth Plan's basic policies are to achieve (a) the rapid expansion of production, (b) the creation of productive employment opportunities, and (c) the fulfillment of people's minimum needs, giving priority to the development of agriculture. The Plan was drawn up to meet the serious economic conditions which the country had encountered, particularly by setting measures to cope with the food deficits and stagnant economic growth. Besides the development of agriculture, other areas for which specific measures have been set are (a) the creation of employment opportunities in rural areas which can be attained by promoting small-scale and cottage industries, (b) protection of natural resources, (c) development of water resources, and (d) efficient utilization of existing industrial infrastructure. The Plan has targetted an annual growth of 4% for GDP, 3.2% for the agricultural sector comprising 2.8% for foodgrains and 3.9% for cash crops, and 5.6% for non-agricultural sectors including 10% for the industrial sector.

GDP growth successfully reached 5.6% in 1980/81, but it declined to 3.8% in 1981/82. In 1982/83, GDP contracted minus 1.3% compared to the preceding year. These fluctuations in GDP growth are attributed mainly to unstability of agricultural production. Whereas the output of cash crops continued to stably increase by 3.5% in 1980/81, 4% in 1981/82, and 5.1% in 1982/83, the output of foodgrains always fluctuated, showing a significant increase of 19% in 1980/81, an increase of 4% in 1981/82 and then a decrease of 12.1% due to unfavorable weather in 1982/83, in each case compared to the preceding year. GDP in the agricultural sector thus showed increases of 16.6% in 1980/81 and 4% in 1981/82, and then a contraction by 3.1%, each compared to the preceding year. Growth of the industrial sector, after decreasing by 3.1% from the preceding year, attained increases of 14.8% in 1981/82, and 18.8% in 1982/83. Although the share of the industrial sector in GDP has gradually been increasing, Nepal's economy is still largely dependent on agriculture, because of the relatively small share contributed by the industrial sector.

3-2 Importance of agriculture in Nepal's economy

3-2-1 Overview of agriculture

Table 1-7 shows the production of major crops in the Kingdom of Nepal. Paddy, maize, wheat, barley and millet are the principal foodgrain crops, while sugarcane, oil seeds, tobacco, jute and potato are the main cash crops. The production of foodgrains accounts for about 88% of total agricultural production, in which paddy and maize, the two principal food crops, account respectively for 55% and 21% of the total foodgrain production. Following these two crops, wheat accounts for 20%, and millet and barley accounts for 4%. During the last six years, the production of these crops, except for wheat, has been stagnant with substantial decreases in the years when weather was unfavorable. As for the cash crops, the production of oil seeds and jute was stagnant, whereas the production of sugarcane, tobacco and potato had stable growth. Against this background, HMG/N has adopted measures to increase the production of agricultural produces, particularly foodgrains, by means of enhancing extension services for agriculture, promoting irrigation projects, as well as intensifying the supply of agricultural inputs like improved seeds and fertilizer.

3-2-2 Economic position of agriculture

Agriculture thus has great economic significance in the Nepal's economy. 94 percent of the population resides in rural areas, and about 90 percent of employment is in agriculture. In view of the country's economic structure wherein agriculture contributes about 60% of GDP and 80% of exports, and supplies more than 50% of raw materials for manufacturing industries, it is obvious that the development of the national economy would be largely dependent on the development of agriculture. In this context the present Five Year Plan has given top priority to the expansion of agricultural production. Increases in foodgrain production is thus an essential goal to be attained to meet food demands of the increasing population. At the same time, another goal for agriculture would be to continue steady production of the agriculture products required as raw materials for agro-based industries, since those industries are the major fields of cottage industries which HMG/N is seeking to develop. Hence the successful growth of agriculture would be greatly emphasized henceforce.

3-3 Economic significance of the project

Urea fertilizer is one of important inputs for the Nepal's agriculture. In Nepal there is no existing fertilizer manufacturer, and the requirements for fertilizer therefore are met by imports. HMG/N has been spending scarce foreign exchange for commercial importation of fertilizer, while receiving some fertilizer supplied on official grants.

Nepal's geographic conditions cause high costs for importation, so the prices for imported fertilizer are higher than international market prices. Another problem is HMG/N's difficulty in procuring fertilizer in time and in delivering it to farmers as required by them. If urea fertilizer is locally produced at reasonable cost, it would not only substantially contribute to the country's foreign exchange savings, but also would assure stable supply of urea fertilizer. Hence it is expected that this project may greatly contribute to the development of agriculture and eventually economic growth of the country.

In addition, this project would also contribute to efficient utilization of indigenous resources, because the project envisages efficient uses of water resource and surplus electric power. Further, impacts on the country's industrial development which this project could have are also valuable. The country at present is at an infant stage of industrialization. As shown in Table 1-8, at present cement industry is the only existing basic industry, and there is no major chemical industry in the country. Ammonia and urea manufacturing technologies which form the basis for this project are basic technologies applicable to other chemical industries and this project therefore could provide fundamental experiences useful for developing various chemical industries in future.

Table 1-1 REGIONAL DISTRIBUTION OF POPULATION a/

	1971		1976		1981	
	Persons	% of Total	Persons	% of Total	Persons	% of Total
Eastern Region	2,797,500	24.21	3,067,086	23.90	3,708,923	24.69
Mountains	304,352	2.63	322,131	2.52	338,439	2.25
Hills	1,114,590	9.65	1,199,078	9.34	1,257,042	8.37
Terai	1,378,558	11.93	1,545,877	12.04	2,113,442	14.07
Central Region	3,865,753	33.46	4,319,601	33.65	4,909,357	32.68
Mountains	353,923	3.06	378,990	2.95	413,143	2.75
Hills	1,741,594	15.08	1,943,658	15.14	2,108,433	14.03
Terai	1,770,236	15.32	1,996,953	15.56	2,387,781	15.90
Western Region	2,465,540	21.33	2,712,781	21.13	3,128,859	20.83
Mountains	53,490	0.46	36,389	0.28	19,951	0.13
Hills	1,816,940	15.72	2,000,359	15.58	2,150,939	14.32
Terai	595,110	5.15	676,033	5.27	957,969	6.38
Mid-Western Region	1,468,896	12.71	1,675,825	13.05	1,955,611	13.02
Mountains	188,012	1.63	221,231	1.72	242,486	1.61
Hills	885,562	7.66	981,808	7.65	1,042,365	6.94
Terai	395,322	3.42	472,786	3.68	670,760	4.47
Far-Western Region	958,294	8.29	1,061,725	8.27	1,320,089	8.78
Mountains	238,833	2.07	255,753	1.99	288,877	1.92
Hills	521,721	4.51	573,985	4.47	604,336	4.02
Terai	197,740	1.71	231,987	1.81	426,876	2.84
Total	11,555,983	100.00	12,837,018	100.00	15,022,839	100.00
Mountains	1,138,610	9.85	1,214,494	9.46	1,302,896	8.67
Hills, of which:	6,080,407	52.62	6,698,888	52.18	7,163,115	47.68
Kathmandu Valley	(618,912)	(5.36)	(692,555)	(5.39)	(766,345)	(5.10)
Terai	4,336,966	37.53	4,923,636	38.36	6,556,828	43.65

Note: a/ In November 1981, the old Far-Western Region was divided into the Mid-Western and the Far-Western Regions. In this table, the 1971 and 1976 populations of the old Far-Western Region were disaggregated into Midand Far-West using zonal population data.

Source: Central Bureau of Statistics

Table 1-2 GROSS DOMESTIC PRODUCT: NEW SERIES a/

	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82 b/	1982/83 c/
	(Rs Million in Current Prices)								
Agriculture d/	11,435	11,495	10,389	11,616	13,365	13,520	15,510	16,792	
Mining	22	23	26	25	34	42	58	68	
Manufacturing	440	459	499	531	559	618	712	820	
Cottage Industry	224	231	237	263	289	318	337	369	
Construction	583	718	1,020	1,338	1,559	1,570	1,974	2,537	
Electricity, Gas & Water	34	38	39	42	48	60	67	90	
Transport, Storage & Communications	690	805	852	1,093	1,248	1,541	1,889	1,992	
Trade, Restaurant & Hotels	540	603	636	707	724	889	953	1,070	
Finance, Insurance & Real Estate	1,095	1,171	1,412	1,534	1,613	1,833	2,077	2,351	
Services	873	1,046	1,145	1,277	1,340	1,495	1,889	2,174	
GDP at Factor Cost	15,936	16,589	16,255	18,426	20,779	21,886	25,466	28,263	
Net Indirect Taxes	635	805	1,025	1,306	1,436	1,465	1,986	2,276	
of which: Argriculture	(115)	(116)	(117)	(136)	(157)	(163)	(169)	(183)	
GDP at Market Price	16,571	17,394	17,280	19,732	22,215	23,351	27,452	30,539	
	(Rs Million in Constant 1974/75 Prices)								
Agriculture e/	11,550	11,615	11,141	11,141	11,480	10,933	12,748	13,258	11,972
Non-Agriculture e/	5,021	5,685	6,681	7,466	7,568	7,673	6,900	7,136	8,157
GDP at Market Price	16,571	17,300	17,822	18,607	19,048	18,606	19,648	20,394	20,129

Notes: a/ New series begun in 1974/75
b/ Provisional estimates
c/ Tentative estimates
d/ Includes fishing and forestry
e/ Constant price series available at market prices only

Source: Central Bureau of Statistics and National Planning Commission

Table 1-3 BALANCE OF PAYMENTS SUMMARY

(Unit: million US$ in current prices)

		1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	Estimate 1982/83
1.	EXPORTS (G&NFS)	155.9	163.0	168.8	218.1	223.5	293.6	277.1	221.2
2.	Merchandise (f.o.b.)	100.6	95.1	86.2	108.6	96.1	134.4	115.4	67.3
3.	Non-factor Services	55.3	67.9	82.6	109.5	127.4	159.2	161.7	153.9
4.	IMPORTS (G&NFS)	205.2	197.9	246.9	295.6	364.6	446.4	449.6	491.5
5.	Merchandise (f.o.b.)	160.2	155.8	193.8	231.1	283.3	352.6	363.6	408.3
6.	Non-factor Services	45.0	42.1	53.1	64.5	81.3	93.8	86.0	83.2
7.	RESOURCE BALANCE	-49.3	-34.9	-78.1	-77.5	-141.1	-152.8	-172.5	-270.3
8.	Net Factor Income	5.3	5.9	7.0	8.3	12.6	10.0	11.6	7.4
9.	Factor Receipts	6.9	6.7	8.1	10.4	15.9	13.3	15.2	13.0
10.	Factor Payments	1.6	0.8	1.1	2.1	3.3	3.3	3.6	5.6
11.	Net Current Transfers	27.4	29.4	24.3	29.8	35.5	46.4	40.5	37.6
12.	Transfer Receipts	28.9	31.2	25.6	30.9	36.6	47.9	42.3	40.1
13.	Transfer Payments	1.5	1.8	1.3	1.1	1.1	1.5	1.8	2.5
14.	CURRENT BALANCE	-16.6	0.4	-46.8	-39.4	-93.0	-96.4	-120.4	-225.3
	M&LT CAPITAL INFLOW								
15.	Direct Investment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.	Official Grant Aid	21.6	20.1	23.2	42.6	63.5	71.7	89.3	102.5
17.	Net M&LT Loans	12.1	17.2	23.6	35.7	48.1	52.8	59.3	72.1
18.	Disbursements	13.6	18.7	25.1	37.3	49.8	55.4	64.6	81.0
19.	Repayments	1.5	1.5	1.5	1.6	1.7	2.6	5.3	8.9
20.	Capital Flows, NEI	12.7	-12.7	0.8	9.6	-16.3	-12.0	10.8	14.6
21.	OVERALL BALANCE	29.8	25.0	0.8	48.5	2.3	16.1	39.0	-36.1
22.	Change in Net Reserves	-29.8	-25.0	-0.8	-48.5	-2.3	-16.1	-39.0	36.1
23.	Net Credit from IMF						12.7	-0.6	-5.4
	Other Changes (net) (-indicates increase)						-28.8	-39.6	41.5

Source: Nepal Rastra Bank

Table 1-4 NATIONAL ACCOUNTS SUMMARY

(Unit: million US$ in current prices)

		1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
1.	Gross Domestic Product	1,569.2	1,447.7	1,382.4	1,596.3	1,851.3	1,945.9	2,287.7	2,356.6
2.	Resource Gap	70.2	49.3	34.9	78.1	77.5	141.1	152.8	172.5
3.	Imports (G&NFS)	209.8	205.2	197.9	246.9	295.6	364.6	446.4	449.6
4.	Exports (G&NFS)	139.6	155.9	163.0	168.8	218.1	223.5	293.6	277.1
5.	Total Expenditures	1,639.4	1,497.0	1,417.2	1,674.5	1,928.8	2,087.0	2,575.6	2,686.0
6.	Consumption	1,493.7	1,346.2	1,246.1	1,473.8	1,599.6	1,780.2	2,237.1	2,297.5
7.	General Government	-	-	-	-	-	-	-	-
8.	Private	-	-	-	-	-	-	-	-
9.	Investment	145.7	150.8	171.2	200.6	329.2	306.8	338.5	388.5
10.	Fixed Investment	-	-	-	-	308.3	257.7	-	-
11.	Change in Stocks	-	-	-	-	20.9	49.1	-	-
12.	Domestic Saving	75.5	101.5	136.3	122.5	251.7	165.7	185.7	216.0
13.	Net Factor Income	-	5.3	5.9	7.0	8.3	12.6	10.0	11.6
14.	Current Transfers	28.5	27.4	29.4	24.3	29.8	35.5	46.4	40.5
15.	National Saving	-	134.2	171.6	153.8	289.8	213.8	242.1	268.1
Average Exchange Rates:									
16.	Rupees per SDR	12.899	14.063	14.444	14.830	15.380	15.614	15.090	14.737
17.	Rupees per US$	10.560	12.015	12.500	12.361	12.000	12.000	12.000	12.959

Source: Central Bureau of Statistics, National Planning Commission and Nepal Rastra Bank

Table 1-5 COMPOSITION OF TRADE

(Unit: Million Rupees)

	1969/70	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Exports, f.o.b.	489.5	899.6	1,185.8	1,164.8	1,064.1	1,296.8	1,150.5	1,608.6	1,490.5
Food and Live Animals	296.4	517.5	804.0	599.5	405.3	488.8	306.5	588.7	735.9
Tobacco and Beverages	2.2	0.4	4.0	12.3	11.2	13.6	2.6	15.4	18.5
Crude Materials, Inedibles, Except Fuels	20.5	213.3	226.3	377.8	441.2	491.7	469.6	561.6	397.3
Mineral Fuels and Lubricants	-	1.5	1.6	0.5	0.2	0.7	0.5	0.4	1.0
Animal & Vegetable Oils & Fats	1.6	2.4	1.8	5.3	6.0	16.5	20.4	37.8	44.0
Chemicals and Drugs	1.3	0.9	9.3	10.6	3.6	0.8	1.3	3.9	1.5
Manufactured Goods, Classified Chiefly by Materials	48.0	28.1	104.7	123.9	123.3	229.1	291.8	254.3	225.4
Machinery and Transportation Equipment	0.2	0.1	3.6	1.6	2.7	2.9	3.2	1.8	9.1
Other Manufactured Products	19.0	38.3	23.0	27.8	51.2	52.4	54.0	143.0	57.1
Other	0.2	12.1	7.3	5.6	1.5	0.3	0.6	1.7	0.8
Imports, c.i.f.	864.6	1,814.6	1,981.7	2,008.0	2,469.7	2,884.7	3,480.2	4,428.2	4,929.3
Food and Live Animals	158.3	243.1	291.1	249.3	323.1	292.0	412.9	601.2	619.2
Tobacco and Beverages	11.1	18.9	42.4	20.2	44.2	35.7	25.9	24.8	35.6
Crude Materials, Inedibles, Except Fuels	52.6	63.8	88.7	36.4	53.1	61.4	100.9	115.5	142.6
Mineral Fuels and Lubricants	88.6	182.7	211.7	249.0	250.3	232.4	409.7	583.6	579.3
Animal & Vegetable Oils & Fats	8.3	7.0	7.4	8.3	30.8	22.4	26.0	92.5	64.3
Chemical Drugs	65.6	179.5	190.1	224.5	254.9	297.5	396.7	527.3	599.2
Manufactured Goods, Classified Chiefly by Materials	342.7	509.5	545.9	660.6	819.2	1,084.7	1,089.9	1,259.2	1,555.5
Machinery and Transportation Equipment	79.5	270.1	413.4	375.5	483.1	574.7	719.7	802.9	891.1
Other Manufactured Products	57.3	198.1	168.4	145.8	201.0	275.0	288.3	407.6	430.2
Other	0.6	29.9	22.7	38.4	9.9	8.9	10.2	13.6	12.3

Note: Based on Customs data
Source: Nepal Rastra Bank

Table 1-6 DIRECTION OF FOREIGN TRADE

(Unit: Million Rupees)

	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Exports, f.o.b.	1,209.7	1,142.9	1,099.4	1,525.8	1,311.4	1,663.8	1,473.6
Belgium	18.5	41.0	55.8	21.6	5.8	9.9	5.5
United Kingdom	15.2	21.4	41.9	31.9	55.9	48.2	42.2
Germany, Fed. Rep.	12.5	45.6	53.9	68.2	72.2	58.3	66.6
U.S.S.R.	3.4	10.0	7.6	24.0	110.6	50.2	23.4
Rest of Europe	35.0	59.5	92.5	119.8	103.2	74.2	54.3
Hong Kong	22.3	22.5	18.9	20.5	13.6	93.9	4.1
India	910.6	779.6	498.1	650.1	507.3	992.4	994.3
Japan	3.8	26.1	19.3	66.1	57.8	31.5	15.6
Singapore	38.6	35.2	42.0	35.9	29.2	65.6	33.9
Rest of Asia	76.0	17.3	109.3	267.5	165.7	164.4	174.0
U.S.A.	44.8	63.0	62.6	96.8	92.7	35.6	23.4
Rest of World*	29.0	21.7	97.5	123.4	97.4	39.6	36.3
Imports, c.i.f.	1,934.1	1,940.4	2,645.1	3,045.2	3,692.7	4,593.6	4,806.4
Germany, Fed. Rep.	20.3	38.7	47.3	66.0	69.2	71.4	152.0
United Kingdom	11.5	25.9	52.7	63.5	214.2	65.4	69.4
U.S.S.R.	4.8	127.2	131.0	113.0	143.9	164.7	381.0
Rest of Europe	15.0	37.7	70.8	83.7	119.6	238.4	122.1
Hong Kong	13.6	21.5	34.5	68.7	57.2	91.8	65.5
India	1,267.1	1,343.5	1,534.1	1,580.8	1,786.4	2,179.0	2,280.9
Japan	74.7	133.2	245.3	403.5	405.2	572.0	577.4
Singapore	41.1	14.9	21.9	86.0	67.5	117.7	124.6
Rest of Asia	16.8	137.5	288.3	451.4	669.0	937.1	809.8
U.S.A.	34.5	53.9	154.9	100.7	103.3	94.1	171.0
Rest of World*	434.7	16.4	64.3	26.0	57.2	62.0	52.7

* Includes unclassified exports and imports.

Notes: Date based on customs returns. Total figures differ from those of other tables because this table has not been revised at source.

Source: Trade Promotion Center and Nepal Rastra Bank

Tabble 1-7 PRODUCTION OF PRINCIPAL CROPS

(Unit: Ton)

Crops	1977/78	1978/79	1979/80	1980/81	1981/82	Estimate 1982/83	Percentage increase or decrease (-) 1982/83 over 1981/82
Food Grains							
Paddy	2,282,430	2,339,000	2,059,930	2,464,310	2,560,080	1,832,620	-28.42
Maize	740,470	743,000	553,760	742,940	751,520	718,240	-4.43
Wheat	411,270	454,000	439,990	477,190	525,930	656,630	25.56
Barley	22,450	22,000	23,290	23,030	23,320	20,900	-10.38
Millet	129,510	133,000	119,340	121,530	121,710	124,870	2.60
Cash Crops							
Sugarcane	386,930	379,000	384,370	483,380	590,000	638,310	8.19
Oil Seeds	78,450	92,000	61,870	77,140	79,120	69,350	-12.35
Tabacco	6,030	5,000	5,500	5,490	4,820	6,660	38.17
Jute	55,801	65,551	67,514	59,284	42,663	31,124	-27.05
Potato	271,120	268,000	278,400	275,180	319,750	374,570	17.14

Source: Food and Agricultural Marketing Services Department and Jute Development and Trading Corporation

Tabble 1-8 PRODUCTION OF PRINCIPAL INDUSTRIES

Goods	Unit	1978/79	1979/80	1980/81	1981/82	First Nine Months 1981/82	First Nine Months 1982/83*
Jute goods	M. Ton	15,520	14,777	16,264	15,725	11,802	13,973
Sugar	M. Ton	27,200	14,158	12,020	21,154	19,159	20,380
Cigarettes	00,000	20,686	16,424	18,113	2,8,493	2,0,219	2,6,000
Matches	000 Gross	724	699	626	760	697	770
Liquor**	000 Litre	455	698	788	477	295	395
Soap	M. Ton	1,121	1,174	2,631	3,050	1,893	3,843
Shoes	Pairs	55,779	70,299	81,845	61,450	60,512	50,000
Leather	000 Pieces	1,320	1,857	1,802	1,655	1,378	9,222
Agricultural Tools	M. Ton	179	39,449 (Pieces)	86	70,000 (Pieces)	65,000 (Pieces)	60,562 (Pieces)
Tea	M. Ton	326	387	535	642	414	514
Stainless Steel Utensils	M. Ton	294	760	470	401	298	257
Straw Board	M. Ton	1,410	965	1,638	1,139	1,034	612
Brick & Tile***	000 Pieces	12,403	33,791	25,642	20,900	18,290	22,950
Beer	000 Litre	1,181	1,310	1,459	1,276	873	1,201
Fertilizers	M. Ton	569	287	254	400	367	400
Cotton Textiles	000 Metre	2,429	3,489	5,317	6,862	5,287	9,143
Cement	M. Ton	21,019	29,163	32,326	30,378	22,897	24,000
Plastic Goods	M. Ton	75	49	79	81	48	217
Biscuits	M. Ton	2,037	1,912	1,675	2,267	1,832	1,944
Plywood	000 Sq. Ft.	1,809	1,051	4,149	4,647	3,712	3,994
Polythene Pipes	000 Metre	575	426	788	1,646	923	1,351
Synthetic Textiles	000 Metre	1,775	2,190	2,329	2,677	1,502	2,209
Iron Goods	M. Ton	4,471	5,963	5,070	7,260	5,123	9,308

Notes: * Provisional
** Distillery Production only
*** Production of Brick & Tile Factory only

Source: Department of Industry, Excise Department and Nepal Rastra Bank.

Part II MARKET ASPECTS

Chapter 1 Introduction

Chapter 2 Background of Nitrogen Fertilizer Market in Nepal

Chapter 3 Present Situation and Outlook of Nitrogen Fertilizer Market in Nepal

Chapter 4 Sales of Product Produced from the Project

Part II MARKET ASPECTS

Chapter 1 Introduction

1-1 Objectives of the market study

The objective of the market study is to examine the marketability of the product produced by the Project, and to provide the data on marketing and distribution required for the study of project feasibility. Part II includes the results of study elements shown as follows:

1. Analysis of the nitrogen fertilizer market in Nepal in the past and making projections on future market scale.

2. Selection of a suitable product to be produced by the Project in view of marketability on the basis of the above projection.

3. Analysis of the price formation mechanism of nitrogen fertilizer in Nepal and making projections of the future market price trend.

4. Provision of the data on the finally selected product, with respect to the following items;

   i) Sales volume
   ii) Sales price
   iii) Data on the physical distribution facilities required for storaging, bagging, shipping, etc.

1-2 Contents of Part II

Part II includes the following contents. Chapter 2 describes the general knowledge on fertilizer and fertilizer market required for the Study as well as the background condition of the fertilizer market in Nepal. The characteristics of nitrogen fertilizer is firstly explained, followed by the past trend and outlook of the international market of nitrogen fertilizer in view of the fact that fertilizer market in Nepal has a close relationship with the international market. Secondly, the relationship between agriculture and fertilizer use, and the general situation of the fertilizer industry in Nepal as well as of fertilizer distribution are analyzed.

Chapter 3 analyzes the past trend and present situation of nitrogen fertilizer consumption in Nepal, and make projection of the market scale based on the above analysis.

In Chapter 4, the most suitable product for the Project is selected in view of marketability, and the data on marketing and distribution required for the evaluation of the Project is provided.

Chapter 2 Background of Nitrogen Fertilizer Market in Nepal

2-1 Nitrogen fertilizer and its international market

2-1-1 Nitrogen fertilizer

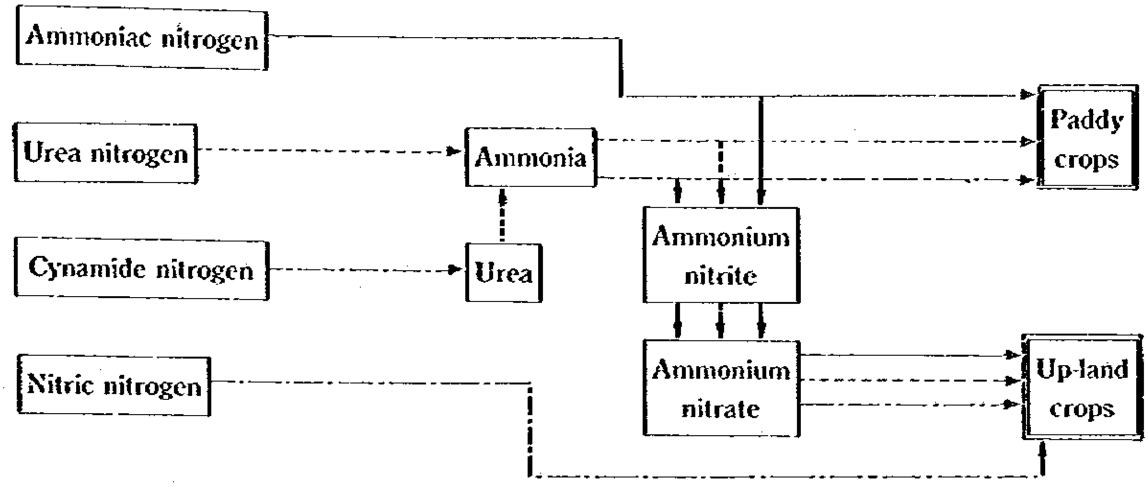
There are ten kinds of plant nutrients, which are required to be supplied in large quantity in the process of growth of plants. Among them, three nutrients are not naturally supplied sufficiently, and these are nitrogen, phosphate, and potassium. Nitrogen fertilizer supplies plants with nitrogen nutrient artificially. Although the nitrogen itself is contained inexhaustibly in the air, only such crops as legumes and azolla can fix and utilize the atmospheric nitrogen. Nitrogen fertilizer is a way to fix the atmospheric nitrogen into a chemical compound and supply it through the soil. More than 95% of nitrogen fertilizer used in the world are the ammonium compounds produced using ammonia which is synthesized from the atmospheric nitrogen. (The nitrogen fertilizers from non-ammonia origin include such fertilizers as calcium cyanamide and natural sodium nitrate which is known as Chile saltpeter.)

Most nitrogen fertilizer may be classified into four groups in view of types of nitrogen contained in the compound, as shown below.

Type of nitrogen contained	Major nitrogen fertilizers classified in the group
1. Ammoniac nitrogen	Ammonia, Ammonium sulphate, Ammonium nitrate*, Ammonium chloride, Ammonium phosphate
2. Nitric nitrogen	Ammonium nitrate* , Sodium nitrate, Calcium nitrate
3. Urea nitrogen	Urea
4. Cyanamide nitrogen	Calcium cyanamide

Note: * Including calcium ammonium nitrate. A part of nitrogen is ammoniac, while reminder is nitric.

After being applied to the soil, nitrogen fertilizer goes through various decomposition process as shown below, depending on the type of nitrogen, and finally is absorbed by the plants as ammonia in the case of paddy crops, or as nitric acid in the case of up-land crops.



Since the decomposition process of nitrogen fertilizer thus varies among the different types of nitrogen fertilizers, the extent of effect of nitrogen on the crops varies depending on such conditions as field conditions, soil conditions, climatic conditions, etc. Urea is easily washed away by water before it is decomposed to ammonia, and therefore, it is recommended to mix it with soil immediately after it is applied in order to avoid such loss. However, once urea is decomposed to ammonia, it is absorbed by soil and kept in the soil. In the case of nitric nitrogen, it is easily washed away into the irrigation water since the nitric nitrogen is not absorbed by the soil. Nitric nitrogen is unstable in the reduction zone in soil, easily deoxidized to nitrogen, and volatilized into the air. Therefore, nitric nitrogen is recommended not to be mixed with soil, and thus it is not the suitable fertilizer for paddy crops. (However, the nitric nitrogen may be used on paddy crops also, in the case of top-dressing under dry soil conditions.)

Nitrogen fertilizers may be classified also in terms of number of nutrients contained, as shown below.

Group	Component nutrient(s)	Major nitrogen fertilizers classified in the group
Straight nitrogen fertilizer	Nitrogen only	Ammonia, Urea, Ammonium sulphate, Ammonium nitrate, Ammonium chloride, Calcium cyanamide, etc.
Compound fertilizer	Nitrogen and phosphate	Ammonium phosphate, Nitro phosphate, NP complex
	Nitrogen and potassium	NK complex
	Nitrogen, phosphate, and potassium	NPK complex

2-1-2 Past trend and outlook of supply/demand of nitrogen fertilizer in the world

Table 2-1 shows the region-wise consumption of nitrogen fertilizer in the world. Total consumption of nitrogen fertilizer in the world in 1981/82 was around 60 million N tons, of which 37% was consumed in the developed countries. According to the table, the consumption in the developing countries and the centrally planned countries in 1965/66 was 2.5 million N tons and 5.5 million N tons respectively, and it increased to 12.8 million N tons and 25.4 million N tons by 1981/82 with the average annual growth rate being 11% and 10%. In the same period, the consumption in the developed countries increased only by 7.2% p.a. in average. At the same time, the consumption of nitrogen fertilizer per hectare of arable land was 56 N kg/ha in the developed countries and 65 N kg/ha in the centrally planned countries whereas it was as low as 19 N kg/ha in the developing countries, as shown in Table 2-2. On the basis of the past trend and present situation of the consumption as described above, the application level of nitrogen fertilizer in the developing countries is considered high and the possibility for further increase in the application level is estimated to be rather limited. Contrary to this, however, the developing countries have still great possibility to increase the application level further.

Table 2-3 gives the future supply/demand of nitrogen fertilizer in the world projected by FAO/UNIDO/WORLD BANK's Fertilizer Working Group, while Table 2-4 gives the projection by the Study Team. Both tables project an oversupply situation in the world nitrogen fertilizer market up to 1985, and the need of additional production facilities thereafter.

Urea is the most popular product in volume in world trade among the nitrogen fertilizers and ammonia, except for ammonia as shown in Table 2-1. The major exporters of urea are Mideastern countries, the U.S.A., West European countries, and the U.S.S.R. and East European countries. Only Western European countries, Japan and the U.S.A. were the major exporters up to the price hike of oil at the beginning of 1970s. However, the price of naphtha, which was the main raw material of ammonia in West European countries and Japan, increased greatly after the oil price hike. Nevertheless, Mideastern countries, the U.S.S.R. and East European countries increased urea production using their abundantly endowed natural gas at low prices. As a result, the latter countries increased their exports of urea to the world market with the benefit of their competitive position due to their cheaper natural gas, and contrary to this, the Western countries and Japan lost their competitiveness and greatly decreased exports of urea.

At the same time, many countries, which used to import fertilizer, have constructed ammonia/urea production plants in the early 1970, and as a result, the self-sufficiency of nitrogen fertilizer has been achieved by these countries or they have decreased their imports conspicuously. Such change in the supply/demand as mentioned above led to the oversupply situation of nitrogen fertilizer in the international market, and the oversupply has still prevailed up to now.

Because of this oversupply situation, many ammonia/urea plants in Western Europe, Japan, and the U.S.A. have been forced to stop their production, havng lost competitiveness in the market. However, it is anticipated that the increase in the demand in the future, additional plant closures, will ease the oversupply situation gradually, and balance the supply and demand until 1985.

2-1-3 International market price of nitrogen fertilizer

The past trend of the international market price of urea, which is the representative nitrogen fertilizer, is shown in Figure 2-1 and Table 2-6. The price of urea had showed a long term decline since the second half of the 1960s and up to the beginning of the 1970s. This trend for price to decline resulted from the decrease in production costs of ammonia and urea caused by the scale-up of production facilities. However, after the oil price hike at the beginning of the 1970s, the prices of raw material naphtha and natural gas in such major exporting countries as West Europe, Japan, and the U.S.A. started to increase greatly, and as a result, the production costs of ammonia and urea in these countries also started to increase. Nevertheless, except for the period of the first and the second oil crises in 1973-74 and 1980-81, the prices have remained fairly stable. This may be seen as having resulted from the oversupply situation in the international market as stated above.

Formerly, the international market price had been formulated on the basis of the production costs of West European and Japanese producers. However, now that the Mideastern and East European countries have become major exporters, West European and Japanese producers are not able to keep their leading position in the market price formation. Nevertheless, since the Mideastern and East European producer's production costs are far below than that of other exporting countries, they have set their prices based on the prices offered by other exporting countries, instead of offering the prices based on their production costs. Thus, their production costs have not been reflected in the international market prices.

At present, the U.S.A. is in a leading position in formulating the international market price. However, there are big differences in production costs among the U.S. producers. The higher cost producers have lost competitiveness in the market and been forced to close down their production facilities. Therefore, those producers who will remain in the price leader's position in the future will be the lower cost producers among them. The Mideastern and East European producers will not take the position of price leader because they have followed the formulated market prices instead of formulating prices based on their costs, and they can adjust their price easily to the prevailing market price due to their low production costs. At the same time, if the market price declines to such low level that even the low cost producers in the U.S.A. cannot quote such prices, then they will stop production, and as a result, a supply shortage will occur. On the other hand, however, if the price increases to such a high level that even the high cost producers in the U.S.A. can resume their production, then again, an oversupply situation will be brought about. Thus, the producers in the competitive position in the market will continue to follow the price offered by the lower cost U.S. producers, and the lower cost U.S. producers will remain as the marginal producers without enjoying favorable profits. As a result, the international market price will be formulated at the production cost level of the lower cost U.S. producers.

The natural gas price in the U.S.A. supplied to the ammonia producers has continued to increase year by year due to the demand competition with that of home use. The price of natural gas in the U.S.A. is expected to increase by 3.5% p.a. more than the increase in the general price level, and this increase will be reflected in an increase in the production costs of ammonia and urea by 1.9% p.a. more than that of general prices. Table 2-5 gives the future market price of urea projected on the basis of the above discussions.

2-2 Agriculture and fertilizer consumption in Nepal

2-2-1 General aspects of agricultural sector in Nepal

In spite of the fact that around 93% of the population in Nepal relies on agriculture, the productivity of agriculture is quite low, and most of agriculture is sustenance-level agriculture except for a limited area in Nepal. Therefore, the purchasing power created by the agricultural sector is very small at present, and thus, the development of agriculture is an essential issue for the development of national economy.

The agriculture sector may be classified into three regions. These are (1) the plains area along the border of India and called Terai, (2) the Kathmandu Valley area developed on the outskirts of Kathmandu with the hill area along the main roads, and (3) inaccessible hill and high hill areas.

In Central and Eastern Terai, production of rice exceeds the demand, but the excess supply of rice is not available in Mid Western and Western Terai due to the poor transportation system. The Kathmandu Valley area and the hill areas along the main roads produce more rice than the demand in the areas. Contrary to this, hill areas excluding the areas along the main roads, high hill areas, and Mid Western Terai, and Far Western Terai are the sustenance agricultural areas.

The surplus of rice produced in the Kathmandu Valley is mostly consumed by the urban area of Kathmandu, whereas the surplus from Terai is exported to India. Hill and high hill areas are estimated to be in short supply of rice, but due to the lack of purchasing power in the areas, the flow of rice from the surplus areas to these areas are very limited. Farmers in the hill and high hill areas prefer to go out of those areas to earn supplementary income, instead of sticking to the unstable agriculture. Thus, one of the critical issues for agriculture in Nepal is that the deficit of food supply in some areas is not necessarily met by the surplus in other areas, since the areas are seperated by low purchasing power as well as poor transportation system.

Another critical issue for Nepal agriculture is that population growth has exceeded that of agricultural production (even that of GDP). As a result, per capita agricultural production has declined in real terms. Such pressure from population growth has forced the farmers to develop the bench terrace fields for farming up to the top of mountains in one hand and to expand the fields into the restricted zones in north hill area in Terai in another hand.

Until the first half of the 1960s, Far Western Terai was nearly uninhabitable due to the danger of malarial fever, but the government succeeded to eradicate this with the assistance of WHO and the area has received immigration for the agricultural development from hill areas.

2-2-2 Agricultural production in Nepal

Table 2-7 shows the major aspects of agricultural production in Nepal. Rice accounts for 64% of total cereal production. Rice is mainly grown in Terai and the Kathmandu Valley, with some also grown in hill and valley areas under the elevation of 1,500 m. Rice is the rainy season crop in low land area, while up-land rice, maize, and millet are the rainy season crops in the hill area. Wheat, barley, buckwheat and beans are the typical winter crops, as shown in the cropping pattern in Figure 2-2. Double cropping of rice has commenced in the north part of Terai, but it is estimated to account for only around 10% of total rice cultivation area.

Table 2-8 gives the yield of major crops. The yield level of rice in Kathmandu Valley is almost as high as that of Japan, Korea, and Taiwan where the yield level is the highest in the world. However, the yield in the areas other than Kathmandu Valley is very low and lower than that of other Southwest Asian countries in the case of rice and wheat. The yield level of each crop in average in the past ten years has not shown any improvement except for wheat, potato and sugarcane, and the yield of maize has declined.

In addition to rice, jute is an important export crop mainly grown in Eastern Terai. Tobacco is grown in Central and Eastern Terai mainly for domestic market, and sugarcane is grown in Central Terai, also for domestic use. Potato is grown all over the country, and used for own-consumption as a supplementary crop of rice and maize.

2-2-3 Cultivation practice of major crops and fertilizer application

Most rice is grown in the rain-fed areas, and 80% of rice cultivation in Terai relies on rain-fed irrigation. In the case of a basin and low land in the hill area, the small scale irrigation from rivers is generally available. In Terai, surface water or underground water is sometimes utilized for irrigation, but such irrigated rice area accounts only for slightly more than 10% of total rice area. In these irrigated areas, the yield is stable and fertilizer is applied. Contrary to this, in the rain-fed area, the availability of irrigation water largely depends on the rain from monsoons, and therefore the yield is unstable and the incentive for farmers to invest on expansion of production is low. In these areas, rice is transplanted from the end of June through August and harvested in October through December.

Maize is the second most important crop next to rice, and is grown all over the country. In the low land area, since the maize can be grown in any season of the year, it is grown in winter with seeding in October through November, while in the slopes of hill area, it is mainly grown in summer relying on monsoon water with seeding in April through May. The rain-fed maize is seeded upon supply of soil moisture by monsoon, but the yield largely depends on the availability of rain and has been unstable. Such risk from drought is the major constraint on the incentive for improving cultivation of maize, and therefore, farmers seldom use fertilizer on it.

Wheat is mainly grown as a off-season crop after rice, seeded in early November through early December, and the cultivation season is dry season. Most wheat grown is that of improved varieties which have extremely low yield without fertilization, and therefore receives more fertilizer than rice at present.

Millet is grown after maize cultivation in hill area, while it is grown before rice in Terai, but no fertilization or no cultivation control is practiced on it.

Sugarcane and tobacco are grown as cash crops by fairly large scale farmers, and fertilizer is generally applied on these crops. Oil crops, which cultivation area accounts for large part of total cropped area, consist mainly of mustard, and these crops are grown in a extensive manner as a crop following rice or summer maize.

2-2-4 Trend of fertilizer consumption

Table 2-10 and Figure 2-3 show the past trend of fertilizer consumption since the introduction of chemical fertilizer in 1965. The consumption in 1982/83 was 22,900 N tons of nitrogen fertilizer, 7,200 P_2O_5 tons of phosphate fertilizer, and 900 K_2O tons of potassium fertilizer. Among them, consumption of nitrogen fertilizer has increased steadily, while that of phosphate fertilizer has stagnated and that of potassium showed a decrease in recent years.

Consumption of nitrogen fertilizer per hectare of arable land in Nepal was 7.4 N kg/ha, and it was low compared with the world average or that of other countries in Southwest Asia (Tables 2-11 and 2-2). Ratios of phosphate and potassium consumption against nitrogen consumption were 1:0.3:0.4 (nitrogen : phosphate : potassium), and the ratios were low compared with other countries, with the world average being 1:0.52:0.40.

2-3 Supply and distribution of fertilizer in Nepal

2-3-1 Supply source of fertilizer

Imports are the sole source of fertilizer supply in Nepal. Of the total imports, that provided by aid has played an important role, accounting for around 50% in 1982/83 (Table 2-12). The remainder has been imported through international tender, but to obtain such imports one has to go through long and complex procedures, and further, it takes long time until the fertilizer reaches Nepal. Therefore, Nepal is examining the possibility of a long term contract with Bangladesh on urea import.

2-3-2 Government policy on fertilizer distribution, and distribution system of fertilizer

Most farmers are located in remote areas and their purchasing power is very low. Nevertheless, the promotion of fertilizer use has been an essential issue for improvement of agricultural production. If the fertilizer distribution is left to the private sector, the distribution to remote areas and the sufficiency of supply might be hard to achieve. Afraid of a such risk, the Nepal government put the fertilizer distribution under its control and assigned to AIC (Agricultural Inputs Corporation), the state owned company, exclusive rights to handle it. Further, in order to improve the farmers' purchasing power, the government made the ADB (Agricultural Development Bank) to implement the credit system for agricultural input purchases. At the same time, to activate the cooperative movement and secure the business for the cooperatives, the government allows the unit cooperatives (Sajha) to handle fertilizer distribution on an exclusive basis at the village level. The present fertilizer distribution system is shown in Figure 2-4.

2-3-3 Physical distribution of fertilizer

Most imported fertilizer is unloaded at Calcutta. The fertilizer is transported to Nepal border by railway or truck after completion of custom clearance. In the case of railway transportation, since there are some railways, having different gauges, several transfers of cargo from one railway to another are required. In addition to this, the limited transportation ability of the railways, port congestion and walkouts at the port have been bottlenecks to efficient transportation. Thus, at present, transportation by truck is more often used than railway transportation, although truck transportation is more costly than the latter.

The number and location of entry points from India to Nepal are restricted by India and are shown in Figure 2-5. The fertilizer is temporarily stored at AIC stock points just inside the border. Fertilizer, which is consumed in the inland areas, is further transported by truck to either AIC stock points or rental warehouses located at the consuming areas. Truck transportation is impossible in the rainy season except for on main roads, and therefore, the volume of fertilizer required in the rainy season has to be stocked before the rainy season starts (Figure 2-4). The AIC sells the fertilizer at these stock points, and the fertilizer is transported to either Sajha office or retailers' shops, and then sold to the farmers. Generally, the fertilizer, after sold at AIC's stock point, is transported by mules or on human backs.

As already stated, the crop cultivation season in Nepal is divided into two seasons, namely rainy season cultivation which is commenced with the monsoon rains, and dry season cultivation which is the off-season. The shipment of fertilizer has seasonally fluctuated as shown in Figure 2-6 and Table 2-13. The shipment for the rainy season peaks in April through May, while for the dry season the peak is in September through October. Around 45% of fertilizer is shipped in the rainy season (from March/April to July/August), whereas in the dry season from August/September to February/March around 55% is shipped. The monthly change in the inventory is shown in Figure 2-6 and Table 2-13, but these figures do not necessarily reflect the optimum inventory level in that the control of inventory has been hard for AIC to accomplish since supply source has largely depended on imports based on aid.

2-3-4 Price formation

Until 1972, the price of fertilizer was set regionally on the basis of AIC's costs of purchase and transportation. As a result, in the hill areas, for example, the price of fertilizer was higher because of expensive transportation costs, and therefore, most farmers in the area could not afford to buy fertilizer. In Terai, on the other hand, the fertilizer price was cheaper due to cheaper transportation costs, resulting in exports of fertilizer from there to India.

Faced with the above situation, the Nepal government changed its policy to set the fertilizer price at a standard price throughout the country regardless of transportation costs. This policy change resulted in setting two types of fertilizer subsidies. One is the transportation subsidy to hill and high hill areas. In other words, the difference in the transportation costs between the areas and Terai may be regarded as the transportation subsidy to the hill and high hill areas. Another is the subsidy which originates from the balance between the officially set price and actual costs (purchasing and transportation costs). The officially price is set lower than the costs to give an incentive to farmers to use more fertilizer. These two subsidies are paid by the government to AIC, but at present most of the subsidies were unpaid and accumulated in AIC as losses.

2-3-5 Extension services for fertilizer promotion

The Department of Agriculture is responsible for the extension services for fertilizer promotion. Under the Department, Regional Directorate Offices, which are located in Dhankuta (East), Kathmandu (Central), Pokhara (West), and Surkhet (Far West), are responsible for regional supervision. In each region, a DADO (District Agricultural Development Office) is established and an Agricultural Officer controls the extension services in the district. Nevertheless, the critical issues related to the extension services are that the performance of the JT (Junior Technician) and JTA (Assistant Junior Technician), who directly contact with farmers, has been poor, and that the farmers, whom JT and JTA can contact, are limited to those who are in the accessible areas due to the lack of adequate transportation system. Thus, the effect of extension services on fertilizer promotion has been insufficient so far.

Chapter 3 Present Situation and Outlook of Nitrogen Fertilizer Market in Nepal

3-1 Present situation of nitrogen fertilizer consumption

The past trend of nitrogen fertilizer is shown in Table 2-10 and Figure 2-3. In 1965, fertilizer was introduced to Nepal by the government for the first time. For 15 years from 1967, when the consumption started to increase, until 1982, the consumption of nitrogen fertilizer has increased by 17% p.a. in average. However, the pattern of consumption growth was not uniform during the period, there were three different stages of consumption development. The first period was 8 years from 1965 to 1973, when the consumption increased by around 1,000 tons p.a. (The annual growth rate varied year by year, and it was 51% p.a. in average.) In the second period of 1973 through 1975, the consumption growth stagnated. The main reason for the stagnation was the international price hike of fertilizers caused by the first oil crisis, and Nepal had to transfer the increase in the international price to the domestic price. As a result, as shown in Tables 2-14 and 2-15, the price in 1974 was more than double the price in 1970. The price increased further in 1975, but the government lowered the price in December, 1975, and then the consumption started to recover. The third period is the period until now, and during the period the consumption has increased by 13% p.a. in average.

Table 2-16 shows the consumption trend of nitrogen fertilizer by type. In the latter half of the 1960s, when the fertilizer was firstly introduced, the consumption of ammonium sulphate accounted for around 70% of the total, but with the consumption of urea having increased gradually, the urea accounted for more than 60% in the latter half of 1970s, and further it exceeded 65% in 1980 through 1982. By contrast, the consumption of ammonium sulphate contracted to around 5% of the total, whereas that of compound fertilizer accounted for the remaining 25%. However, such changes in the pattern of fertilizer consumption as described above have not necessarily reflected the farmers' preference on the type of fertilizers. Farmers were often compelled to use fertilizer which they do not prefer. In the extreme case, the compound fertilizer was observed to be used even for topdressing. Therefore, the changes in the consumption pattern of fertilizer by type have been influenced greatly by the situation on the supply side, namely that of aid suppliers.

Table 2-17 gives the nitrogen fertilizer consumption by region. Around 80% (in 1982) of the total was consumed in the Kathmandu Valley and Terai areas, and the consumption in High Hill and Hill areas accounted for only 20%. Among the former consumption areas, Central Terai and Kathmandu Valley are the two largest consumption areas in Nepal, and consumed 32% and 30% of total Nepal consumption respectively.

The demand calculated with the assumption that the fertilizer is applied on all the cultivation area at the dosage recommended by DOA, may be regarded as the maximum potential demand. Figure 2-7 shows the realization rate of the maximum potential demand by region. According to this figure, the Central region is the highest in the realization rate, followed by Western region. The rates were no more than 5% in other regions. In the Central region, the rates of Kathmandu Valley and High Hill were especially high, both exceeding 50%. (However, in the case of Central High Hill, the maximum potential demand itself was as low as 1,100 N tons in 1982.) The rates of other parts of the Central region were fairly high also, and 10 to 20% of the potential demand was materialized as actual consumption, whereas the rate was 5 to 10% in the Western region.

Recent data on crop-wise fertilizer were not available. Table 2-18 shows the crop-wise fertilizer consumption in 1974/75 through 1976/77 estimated by AIC and AMSD. These were estimated on the basis of seasonal shipment volume, and wheat is estimated to have consumed around 50% of total, whereas it was 35% for rice.

3-2 Outlook of demand for nitrogen fertilizer

3-2-1 Factors affecting the influences on the nitrogen fertilizer demand, and their outlook

(1) Factors affecting the influences on the nitrogen fertilizer demand

Among the various factors which are thought to influence the demand for nitrogen fertilizer in Nepal, the following are the major ones:

1. Economics of fertilizer use (the relationship between costs of fertilizer use and increase in agricultural output attributed to the fertilizer).

2. Availability of irrigation and/or drainage facilities, which also affects the influences on Factor 1 above.

3. Development and diffusion of high-yielding varieties, which have close relationship with Factors 1 and 2 above.

4. Purchasing power of farmers and/or availability of a credit system for fertilizer purchase.

5. Possibility of timely supply of fertilizer.

6. Knowledge of the effects of fertilizer on yield.

The present situation of these factors in Nepal, outlook for changes in these factors, and the probable effects of the changes on fertilizer consumption are analyzed in the following sections.

(2) Economics of fertilizer use

Table 2-19 shows the estimated fertilized area ratio (ratio of fertilized area to cultivated area) by crop based on the data in Table 2-18. The actual fertilized area ratio may be slightly higher than the estimate since the ratio was estimated assuming that farmers apply fertilizer at recommended levels. According to the estimate, rice was fertilized to te extent of 12% of total cultivation area, whereas the ratios were 59% for wheat and 3% for maize. In the case of sugarcane, tobacco and jute, all the cropped areas were estimated to have received fertilizer. The ratios of fertilized area to the cultivation area of improved varieties were estimated as 70% for rice, 83% for wheat and 16% for maize. Since the maize is grown as a rainfed crop in winter and the yield is low and unstable, the fertilized area ratio is as low as 16% even for improved varieties. By contrast, in the case of rice, the improved varieties are grown as a cash crop since the yield level is higher than the local varieties, whereas the local varieties are mainly grown for the farmers' own consumption because of their taste preferences in spite of low yield, and thus, the fertilized area ratio of improved rice was as high as 70%.

Annex II-5 gives the fertilizer response of rice, wheat and maize collected and compiled by Soil Science and Agricultural Chemicals Division of DOA. Table 2-20 presents the results of comparison of economics of fertilizer use by these crops based on the fertilizer response data.

According to the Table, the optimum economic dosage level is around 100 N kg/ha in the case of improved rice and the recommended dosage is 80 to 110 N kg/ha. However, in the case of local varieties, the optimum level is 50 N kg/ha in Inner Terai, as low as 15 N kg/ha in Western Terai, and furthermore, in Eastern Terai the acceptable return cannot be expected. In other words, the diffusion of improved varieties is essential for promotion of fertilizer use.

The economic optimum dosage levels with respect to wheat and maize thus obtained and shown in the same table (2-20) are higher than the recommended dosage levels except for maize in M. Hill area, and therefore, farmers have the potential to increase the application of fertilizer up to the recommendation level.

(3) Diffusion of improved varieties

The diffusion of improved varieties is one of the key factors to promote fertilizer use, as described above. The diffusion rates of improved varieties to total cultivation area in the past were, as shown in Table 2-21, 18% for rice, 15% for maize and 85% for wheat (in 1974/75).

In the case of wheat, the improved varieties are superior to local varieties in such points as taste and marketability (larger granule and whiter appearance), and further, the required cultivation practice is similar to that of local varieties. Thus, the improved varieties have become popular among the farmers, and were grown over almost all the country except for the Far Western region in 1974/75.

By contrast, in the case of rice, the improved varieties are poor in taste and sticky, and therefore farmers prefer the local varieties. Nevertheless, the yield of improved varieties is higher than that of local varieties, and therefore, the cultivation area of improved varieties has been expanded gradually. The diffusion rate was 18% in 1974/75, but the rate among the farmers, who grow rice as a cash crop, was estimated to exceed 70%, according to the farmers' interviews by the Study Team. However, as far as the rice for own-consumption is concerned, even these farmers prefer to grow local varieties, and thus, the diffusion rate of improved varieties is thought to be approaching the saturation point and the growth rate of diffusion will be stagnated soon.

The local maize is a white granule variety, while the improved one is a yellow granule variety. The yellow granule variety does not match traditional taste preferences, and is inferior to the local varieties in multiple applicability and long term storability. Furthermore, the improved varieties require large quantities of fertilizer to attain high yields, and yields will be extremely low without sufficient fertilization. Because of these factors, the diffusion of improved maize has stagnated, and the rate was around 15% in 1974/75. The farmers' interviews made by the Study Team also revealed that most farmers grew local varieties, and that those farmers who grew improved varieties, grew it to the extent of less than 50% of their maize cultivation. From this fact alone, the diffusion of improved varieties of maize is estimated not to have progressed greatly.

(4) Expansion of irrigated area

The statistics on irrigated area in Nepal is understood to not necessarily reflect the actual conditions of irrigation. One reason is that the statistics represent the main canal only, and that the secondary and/or tertiary canals are not necessarily connected for use. Another reason is that the statistics include the canals which are not in use due to landslides. Thus, the data on irrigated area may be used for reference only, but according to the statistics, the irrigation facilities covering 103,056 ha were constructed in the Fourth Five Year Plan period (1970/71 - 1974/75), and it was 95,425 ha against the target of 146,000 ha during the Fifth Five Year Plan period (1975/76 - 1979/80). In the Sixth Five Year Plan period (1980/81 - 1984/85), the target for construction is 233,428 ha. Since the total hectares in Nepal of upland and paddy land is around 2.3 million ha, the irrigation area is expected to be expanded by 4.3% of total area in every five-year-plan period, if 100,000 ha of irrigation facilities are assumed to be constructed in every period. Since the availability of water resources are under study and the government is giving policy emphasis to the expansion of irrigation, the 100,000 ha expansion in every five year period may be expected to be materialized.

(5) Farmers' purchasing power and credit system for fertilizer purchase

Farmers' purchasing power has large and direct influences on fertilizer consumption. If the yield is too low to obtain a surplus to sell in the market, for example, then, the farmer has to decrease or give up the use of fertilizer in the following year. Actually, the ADB supplies farmers with credit through unit cooperatives, but the farmers who utilize the credit system are small in number, and major reasons may be as follows:

1. The interest rate of 14% p.a. is too high a burden for borrower farmers. (The fail to make repayment within 6 months will result in increase in the interest rate to 20% p.a. for the succeeding 5 months, and the rate will be further increased up to 23% after that.)

2. Since long and complex procedures are needed to obtain the credit, purchasing often cannot be made in time.

3. Due to the unstablility of harvests and resulting fail are to make repayment, farmers are often disqualified from obtaining future credit.

In order to create a stable demand for fertilizer, improvement of the credit system is essential. However, at present there is no such plan.

(6) Timely supply of fertilizer

Except for the limited areas where are accessible through main roads, fertilizer has to be transported either by mules or on human backs for long distances, and this has been the great impediment to increased fertilizer use in the remote areas. The construction of roads will be continued in the future and accessible areas may be expected to be expanded gradually. Further, once the domestic production of fertilizer is started, the distribution plan may become organized well in advance resulting in greater ease to secure the required inventory at stock points before the rainy season starts, and therefore, running out of stock is expected to become less frequent.

(7) Diffusion of knowledge on fertilizer use and its effects on yield

The critical impediment for the diffusion of knowledge on fertilizer use and its effects on yield among the farmers is the lack of experienced or well trained extension workers. Since it requires time to train such extension workers, this improvement will be made gradually.

3-2-2 Outlook of demand for nitrogen fertilizer

Table 2-22 and Figure 2-8 show the projected demand for nitrogen fertilizer. Details of methodology, procedure and based data are included in Annex II, and the briefs on the projection methodology and result are described in the following sections.

As already analyzed in 2-3-1, most of factors influencing fertilizer consumption except for the diffusion of improved varieties are not expected to diverge from the past trend and, therefore, the past trend of change in these factors may be applicable to the future. Thus, the future demand was projected basically using the extrapolation of past trend. According to the projection result, the demand for nitrogen fertilizer in Nepal is expected to increase by 3.9% p.a. in average for 7 years until 1990, and by 1.8% p.a. for 5 years of 1990 through 1995. As a result, the demand will reach 27,300 N tons in 1990 and 29,800 N tons in 1995. The growth rate in the future is projected to become lower compared with the past growth rate of 13.9% p.a. in average for 7 years of 1975 through 1982.

In the above demand projection, the past trend of consumption was assumed to have represented the demand in the past. However, as described already, such supply problems as delayed delivery or supply of inappropriate types of fertilizer, has often prevented the realization of potential demand. On the other hand, especially in the Kathmandu Valley, due to the difficulty of applying organic materials, yield has decreased, and chemical fertilizer has been heavily applied to maintain the yield, resulting in further soil depletion. Therefore, this situation in Kathmandu Valley suggests the possibility for fertilizer application to be decreased in the future upon supply of organic materials and/or lime. Actually, it is difficult to measure the difference between actual consumption and unrealized demand in the past, but Cases A, B and C represent the future demand projected on the basis of unrealized demand in the past with the following assumptions. (See Table 2-22 and Figure 2-8.) Cases A and B assumed that the demand in the past has been 10% and 20% higher than actual consumption in Kathmandu Valley and Central Terai, respectively. Case C assumed that the demand in Kathmandu Valley has been 10% lower, and that of Central Terai has been 10% higher than the actual consumption.

In conclusion, the future demand in Nepal is expected to increase in accordance with the projection in the Base Case until domestic production of nitrogen fertilizer starts. After that, the demand trend will shift up to the projected level in Case A or Case B with constraints in supply eased by the domestic production. However, if the promotion of use of organic materials and/or lime turns to be fruitful, then the demand trend might shift down by the difference between projection in Case A and that of Case C. Table 2-23 shows the projected demand on the basis of the above discussion with the assumption that the domestic production of urea will be commenced in 1991 and that the domestic production is large enough to meet all the need from domestic market. In the forthcoming sections, the "projected demand" means the projected demand thus obtained and shown in Table 2-23.

3-3 Demand for nitrogen fertilizer by region and its outlook

3-3-1 Consumption of nitrogen fertilizer by region

As shown in Table 2-23 and described already, of the total consumption of nitrogen fertilizer in Nepal 30% has been consumed in Kathmandu Valley, and 50% in Terai.

In the case of Kathmandu Valley (including Kavre), the ratio of actual consumption to potential demand, which is calculated on the basis of recommended dosages by DOA, was as high as around 55%. At the same time, according to the result of farmers' interviews by the Study Team, although the number of farmers interviewed was small, most farmers were found to have used fertilizer on the crops represented by rice and wheat. The application level was also found to be higher than the recommended dosage level (100-120 N kg/ha) by around 20%, with their application level being 110-120 N kg/ha. In actuality, the farmers who were interviewed, were limited to those who are in areas accessible by car, and therefore, there might be bias on higher side in the observed application level. Especially, those farmers who live in remote areas, might not use fertilizer, and the arable fields located near the top of mountains without sufficient irrigation water and access road, might not be given fertilizer. Besides, generally no fertilizer is applied on the local variety rice grown for own-consumption. With respect to maize, besides its being grown in the dry season with scarce irrigation water, maize is mostly local varieties which have poor response to fertilizer, thus, the fertilizer is seldom applied on maize. In addition to the above situations, organic materials are not added to the soil in Kathmandu Valley. As a result, the capacity of soil to keep plant nutrients has been lowered, and therefore increasing application of fertilizer is required to maintain the yield level, resulting in further depletion of the soil and further increase in the fertilizer application.

In conclusion, the outlook of demand for nitrogen fertilizer in Kathmandu Valley may be summarized as follows. The fertilizer has been applied to all the fields which have the potentiality for fertilizer to be applied. In other words, the fertilizer has been applied to all fields except for inaccessible fields, and fields on which local rice or maize is grown. The application level has been higher than the recommended level. Nevertheless, the fertilizer consumption in this region is expected to increase for the time being. That is, fertilizer will be applied more heavily on the presently fertilized field in order to maintain the yield level. At the same time, a small portion of presently non-fertilized field may newly fertilized owing to extension services. However, in the long term, the growth of consumption in the region will be stagnated in the near future. The reasons may be firstly that application level will reach an uneconomically high level, and secondly that the input of organic materials and lime will become indispensable and with the application of these materials the requirement of chemical fertilizer will be lowered gradually.

In the case of Terai, the consumption in Central Terai accounts for 32% of total consumption in Nepal, followed by Western Terai with 9%. That of Eastern Terai, Mid Western Terai and Far Western Terai account for 5%, 3% and 1% respectively. In the Central Terai, fertilizer is applied on rice and wheat with the application level equivalent to the recommended level. (There are some exceptional districts, such as Bara District, where the fertilizer is applied at higher dose than recommended.) The fertilizer is also applied on such other crops as sugarcane and vegetables, etc. However, such high doses seem to be limited to the areas accessible by road. The ratio of actual consumption to potential dosage was as low as 10 to 20% in Central Terai in average, as shown in Figure 2-7, and no fertilizer or a very low level of fertilizer is estimated to have been applied in the inaccessible areas. Since such is the case in other Terai regions, and further, a large portion of the Mid Western and Far Western regions is inaccessible by road, the fertilizer application level in average is estimated to be low in Terai.

In the case of Hill regions, the fertilization is limited mostly to the Central and Western Hills. The consumption in the Central Hills accounts for 9% of total Nepal consumption, while that of the Western Hill accounts for 4%. Poor transportation facilities may be the main reason for such low fertilization in these regions.

In High Hill regions, besides the cultivation area being small, the transportation facilities are quite poor, and therefore, fertilizer consumption as a total of High Hill regions accounts only for 5% of total Nepal consumption.

3-3-2 Outlook of fertilizer consumption by region

According to the past trend of fertilizer consumption by region, Kathmandu Valley and Central Terai have shown significant growth in fertilizer consumption, and the share of these two regions in total Nepal consumption has continued to increase. The main reason why the consumption in other regions is retarded compared with these two regions is poor transportation facilities in other regions. Poor transportation facilities have resulted in:

(1) Difficulty in fertilizer transportation and increase in the transportation costs. Especially the costs of fertilizer transportation from AIC depots via retailers' shops to farmers have to be borne by the farmers, which means that the fertilizer price for farmers in remote areas increases greatly.

(2) Sustenance agriculture, since agricultural products can not easily be brought to market. Thus, farmers in the area can not earn a living from their land alone, and go out of the area for temporary employment. Therefore, the incentive for the farmers to improve their agricultural production is small.

(3) Lack of sufficient knowledge on fertilizer use and its effects on crop yield, since it is difficult for extension workers to make contact with the farmers in the areas.

(4) Low purchasing power for fertilizer, due to the limited cash income and unstable yield.

These factors have been severe impediments to promotion of fertilizer use. Therefore, the consumption of fertilizer in Nepal will be increased mainly in Kathmandu Valley and Terai with some Hill regions where they are located in the areas accessible by road, as has been observed in the past. The consumption in other regions are also expected to increase as progress is made in improvement of the transportation system, although the increase will be small. The projected demand for nitrogen fertilizer by region is shown in Table 2-23.

3-4 Consumption of nitrogen fertilizer by type, and examination of suitable type of fertilizer in view of agronomy

3-4-1 Consumption of nitrogen fertilizer by type

The past trend of nitrogen fertilizer by type is shown in Table 2-16. Until the first half of the 1970s, ammonium sulphate was the major nitrogen fertilizer, but after that, urea took its position as the most important. At the same time it should be noted that the share of compound fertilizer of the total consumption has increased in recent years.

However, as described already, the past trend of type-wise fertilizer consumption has not necessarily represented the users' preference as to fertilizer type. The conditions on the suppliers' side (especially that of aid suppliers) has had strong influence on the trend. Farmers often have complained about the inavailability of preferred types of fertilizer. Nevertheless, in such cases, farmers have generally used the other types of fertilizer which are available. In view of this, farmers are understood to be fairly flexible in changing the types of fertilizer they use.

Although such complaints from farmers may be reasonable in the case that suppliers sell the type of fertilizer which happen to be available and is not adequate for application (as in the example of compound fertilizer for top-dressing), but there are also some cases when farmers could not get their preferred fertilizer due to their unreasonable or conservative preference. For instance, farmers stick to the fertilizer which they first used, or farmers prefer fertilizer which colors the leaf of crops instantly, in spite of other adverse effects from such fertilizer. Such behavior of farmers may be amended by the development of demonstration farms over the country or an expanded, improved extension program.

3-4-2 Examination of suitable type of fertilizer in view of agronomy

The suitable type of fertilizer for Nepal's agriculture is examined in this section assuming that there are no constraints in the supply of any fertilizers.

Soil Science Division has made some comparative experiments to identify the difference in the effects on the yield among the different types of fertilizers on various crops and soils. Although the detailed results were not made available for the Study Team, according to their results, there was no significant difference between the effect of ammonium sulphate and that of urea. However, no similar experiment was conducted on ammonium nitrate.

The effect of fertilizer on crop yield varies depending on the climatic conditions, chemical content of irrigation water, intensiveness of cultivation practice, etc. Besides, the kind of crops grown before the crop in question also affects the effect of fertilizer. Thus, the best way to select the suitable fertilizer in a specific area from the standpoint of agronomy is to make it based on the comparative experimental results of fertilizer effects on the crops in the area in question. Since no detailed data are available in Nepal at present, the following are the discussions on the siutable fertilizer in Nepal in general. In the discussions, the following points should be kept in mind in the selection of suitable fertilizer in Nepal:

(1) The pH of soil in Nepal tends to be acidic as shown in Figure 2-9. The soils in Kathmandu Valley and Pokahra, which are major agricultural areas, are alluvial soils originated from the bottom of lakes, and are strongly acidic.

(2) The rice cultivation area accounts for around 50% of the total cultivation area in Nepal, and around 35% of nitrogen fertilizer is applied to rice.

(3) In the case of wheat and maize, all the fertilizers are applied as basal dressing, whereas in the case of rice, a half of total nitrogen fertilizer used on rice is applied as basal dressing and remaining half is applied as top dressing at around 25 days after transplanting. Both the basal dressing and top dressing are mixed with soil immediately after application.

(4) The application of fertilizer is immediately followed by irrigation in the irrigated area, but in the rainfed area, irrigation after fertilizer application is uncertain and water supply from rain is especially unstable in dry season.

(5) Cultivation practice is fairly intensive. Many farmers apply additional fertilizer after top-dressing in accordance with coloring of crop leaves.

As has observed in the comparative experimental tests of fertilizer effects carried out by the Soil Science Division, and as described in Chapter 2 (2-1-1), generally, there is no significant difference of effects between ammonium sulphate and urea. In the case of urea;

(1) Urea is not absorbed by soil until it is decomposed to ammonia, and therefore, urea tends to be washed away by a large quantity of water during that time. However, the decomposition of urea to ammonia is smoothly taken place in Nepal due to high temperature, and this issue is not serious in Nepal.

(2) Ammonia, to which urea is decomposed, is often volatilized into the air when urea is applied on alkaline soils. However, the soils in Nepal are mostly acidic, and therefore, the risk of volatilization is small. Moreover, since the fertilizer is mixed immediately after application, such volatilization loss will not be observed in Nepal.

On the other hand, the application of ammonium sulphate is not recommendable in Nepal, since it further acidulates the soil which is already acidic. Actually, farmers sometimes prefer ammonium sulphate because it colors leaves of crops instantly, but ammonium sulphate is not suitable in the soils of Nepal.

Ammonium nitrate contains both ammoniac nitrogen and nitrate nitrogen. In the reduction zone of the soil, the nitrate nitrogen is deoxidized to nitrogen gas and then volatilized into the air, and therefore, ammonium nitrate should not be mixed with soil in the paddy field. However, if the irrigation water is introduced to the field without mixing ammonium nitrate with soil, nitrate nitrogen is washed away with the water since it is not absorbed by soil. Thus, in conclusion, ammonium nitrate is not adequate as a fertilizer on paddy field. Nevertheless, ammonium nitrate may be used as top-dressing fertilizer on rice after removing the irrigation water. In the case of up-land crops, ammonium nitrate may be adequate unless there is a fear of heavy fall of monsoon rain after application.

Compound fertilizer is also recommendable generally in that one or two nutrients in addition to nitrogen can be applied at once. However, the compound fertilizers now used in Nepal mainly contain ammonium nitrate as the nitrogen source, and therefore, such kind of compound fertilizers are not recommendable in Nepal in that the points related to use of ammonium nitrate for rice may be also applicable for this kind of compound fertilizer.

On the basis of the above discussions and the fact that 35 to 40% of nitrogen fertilizer is used on rice in Nepal, urea is recommended as the most suitable fertilizer in Nepal.