No. 57

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NEPAL ELECTRICITY AUTHORITY (NEA)

# FEASIBILITY STUDY
# ON
# ILAM SMALL HYDROPOWER DEVELOPMENT PROJECT
# IN
# THE KINGDOM OF NEPAL

## FINAL REPORT

February, 1994

CHUO KAIHATSU CORPORATION

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# PREFACE

In response to a request from His Majesty's Government of Nepal (HMG/N), the Government of Japan decided to conduct a feasibility study on Ilam Small Hydropower Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team headed by Mr. Hiroshi Sugiyama of Chuo Kaihatsu Corporation, 4 times during the period from February to December 1993.

The team held discussions on the project with officials concerned of HMG/N, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of HMG/N for their close cooperation extended to the team.

February 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation
Agency

February, 1994

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency

Dear Sir,

Letter of Transmittal

We are pleased to submit to you the final report of feasibility study on Ilam Small Hydropower Development Project in Kingdom of Nepal.

The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as the formulation of the above mentioned project. Also included are comments made by the Engineering Directorate of Nepal Electricity Authority during technical discussions on the draft report that held in Kathmandu.

His Majesty's Government of Nepal is focusing immediate developments of small~medium scale hydropower projects. The scheme is well compatible to the above emphasis by the Government.

The scheme presented in the report characterizes a high economic benefit and little environmental impact, and requires to implement timely in order to alleviate the electrical crisis caused by the present shortage of electric power in Nepal.

In the view of the above situation, we recommend that His Majesty's Government of Nepal implement this project as a top priority.

We would like to take this opportunity to express our sincere gratitude to the officials concerned of JICA and the Ministry of Foreign Affairs. We would also like to express our gratitude to the officials concerned of Nepal Electricity Authority, JICA Nepal Office and the Embassy of Japan in Nepal for their cooperation and assistance throughout our field survey.

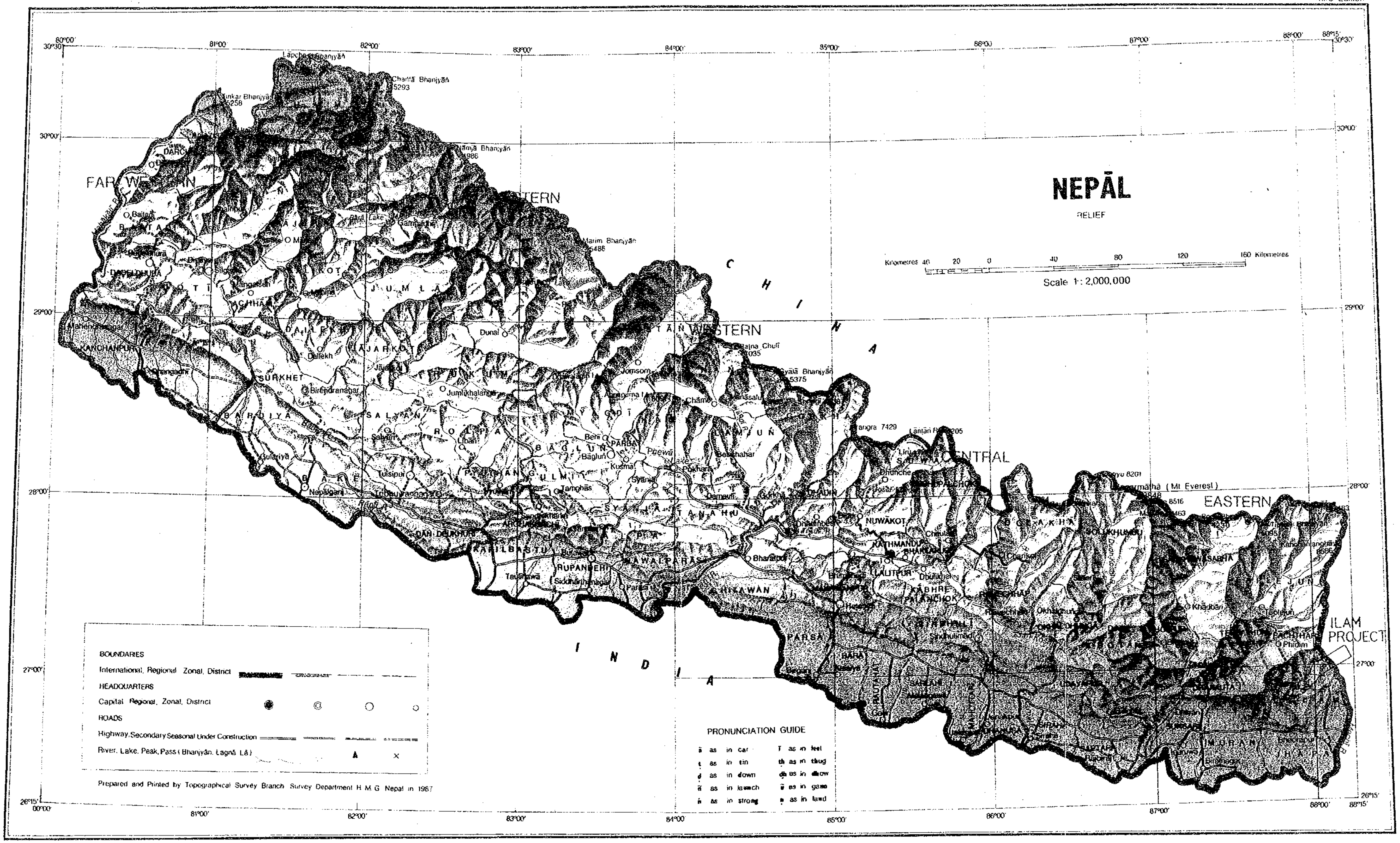
Very truly yours,

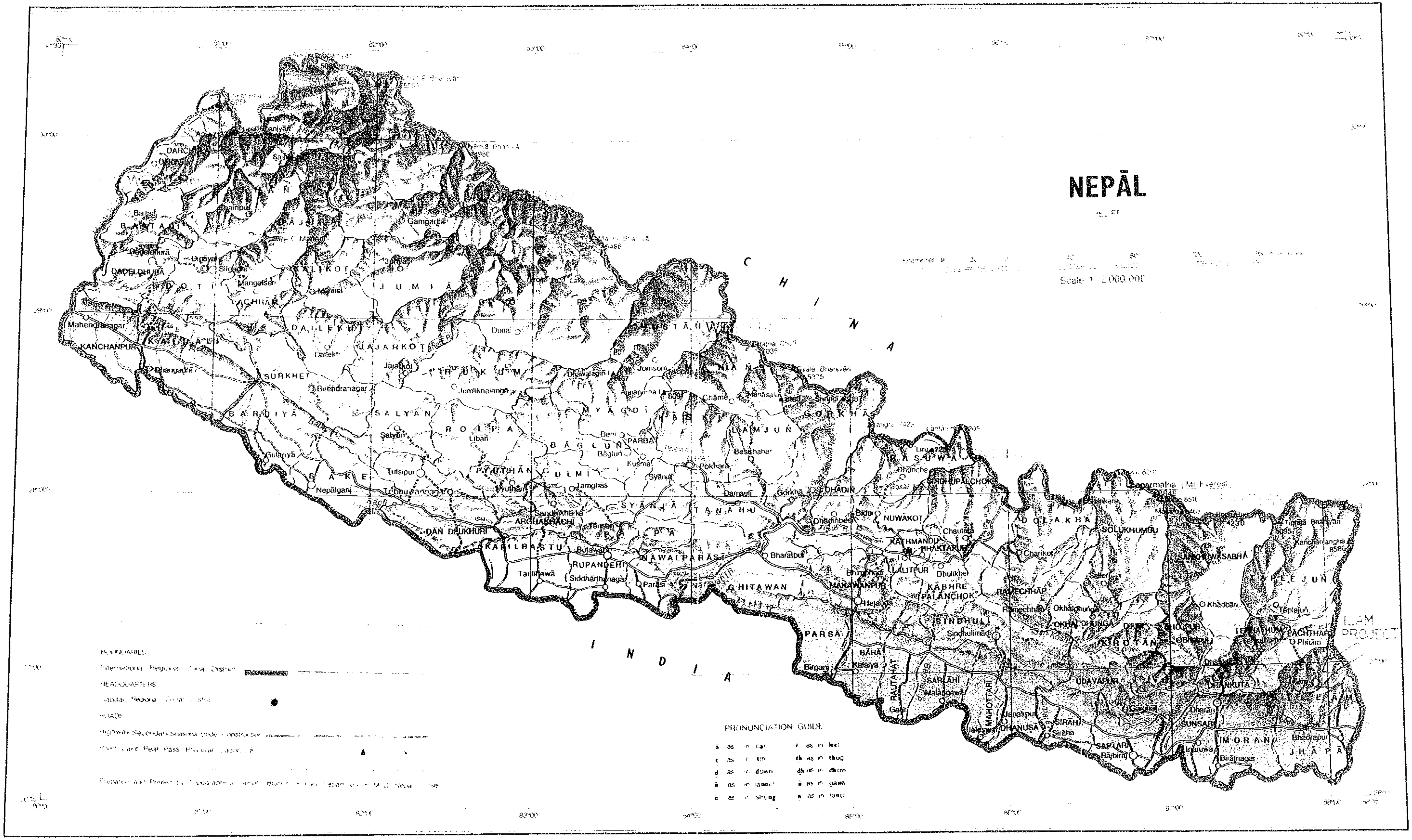
H. Sugiyama

Hiroshi Sugiyama
Team Leader
Feasibility Study Team on
Ilam Small Hydropower
Development Project


BIRD'S EYE VIEW

Third Edition

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PRONUNCIATION GUIDE

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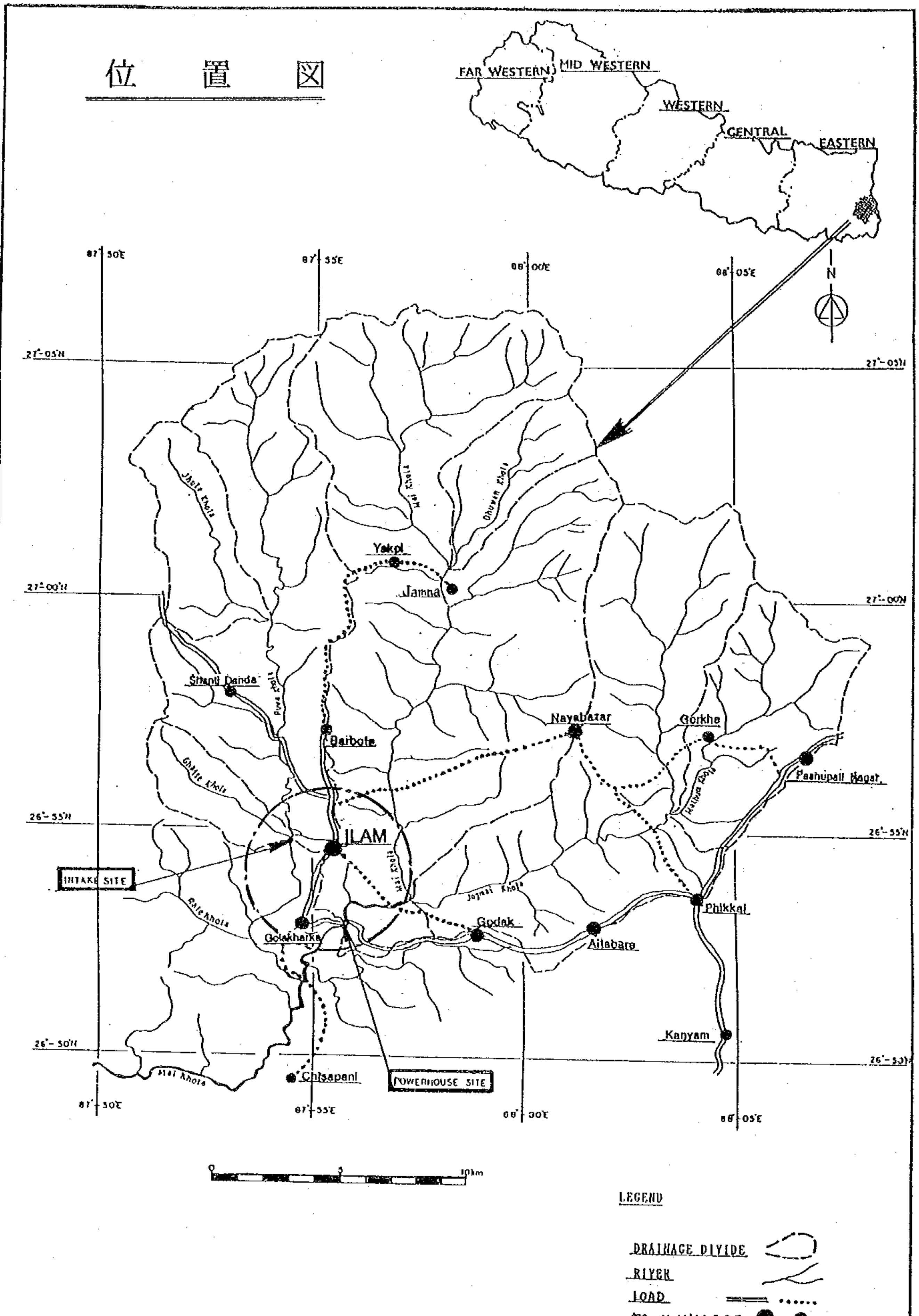

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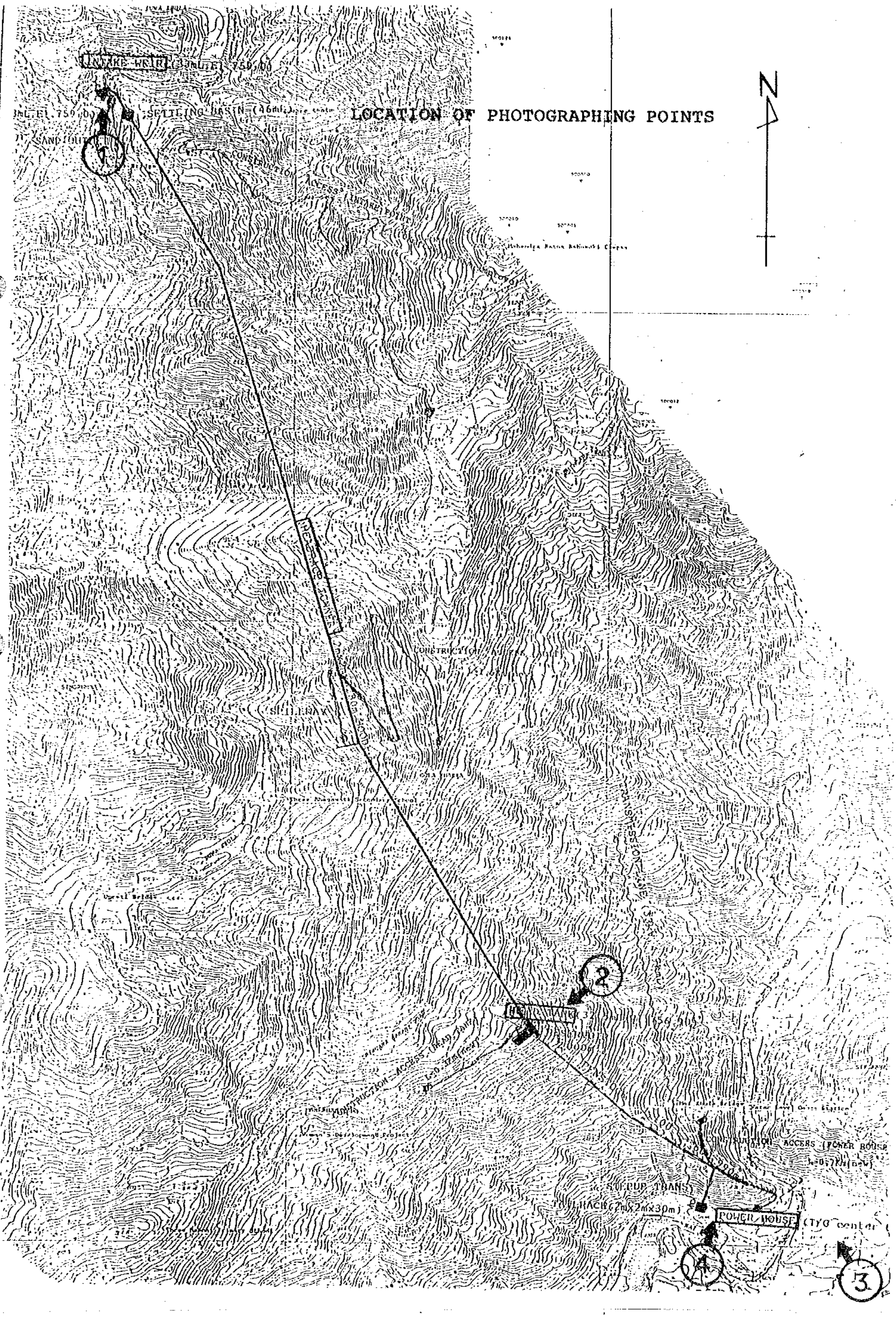
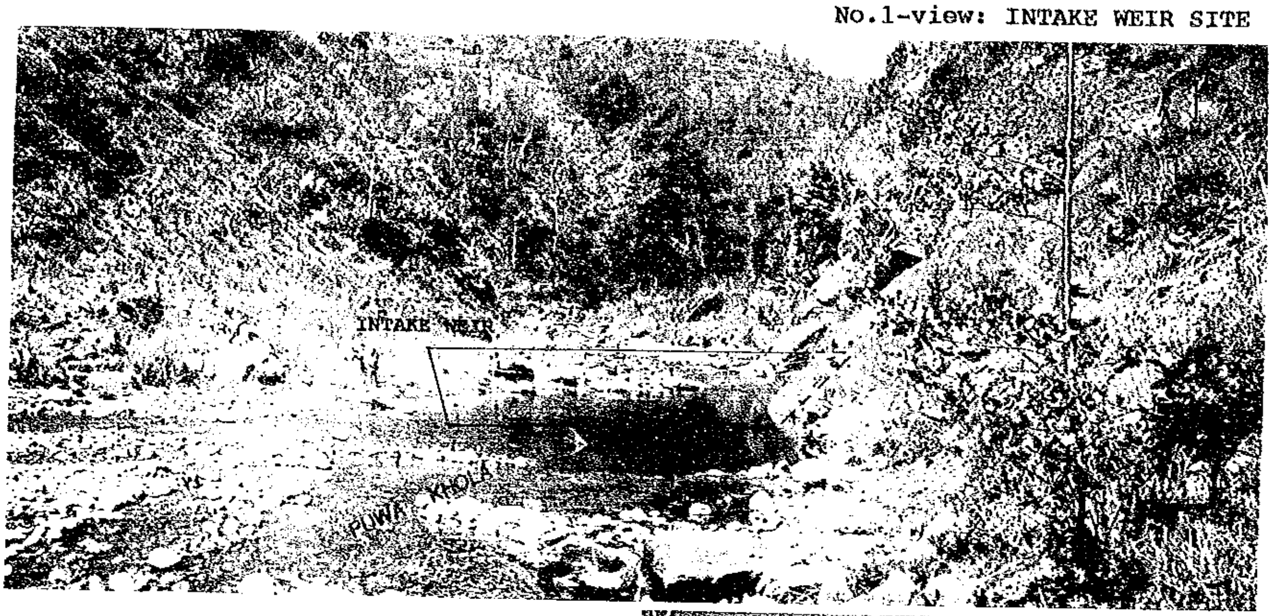
# LOCATION OF PHOTOGRAPHING POINTS

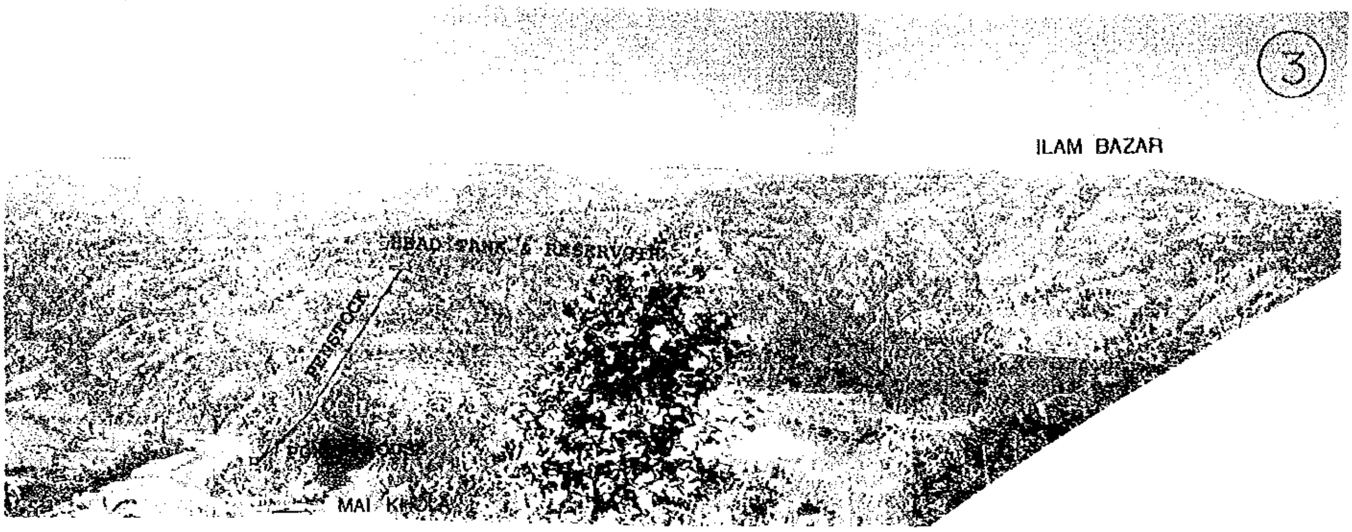


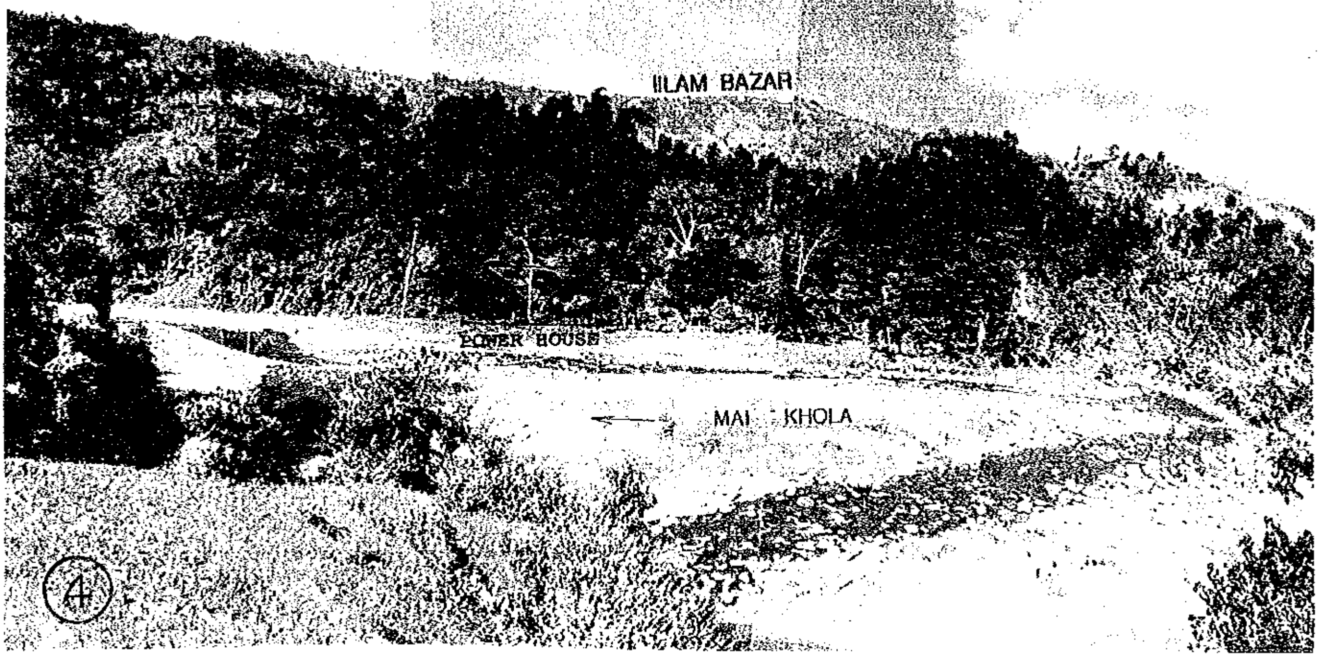
No.1-view: INTAKE WEIR SITE




No.2-view: HEAD TANK & RESERVOIR SITE

No.3-view: ILAM N.P.& PROJECT SITE




No.4-VIEW: POWER HOUSE SITE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Summary

### 1. Economic Conditions

Nepal's per capita GNP is US$ 170(1990), placing the nation in the category of developing country.

Growth rate of the economy during 1987~1989 was 3.2%. Agriculture is the mainstay of the nation's economy. Foreign currency earnings are derived mainly from the export of maize, jute, etc., tourism and development assistance from donor countries.

At present, the 8th National Plan (1993~1997) is in progress, with targets of stable and sustained economic growth, alleviation of poverty and rectification of skewed levels of development by region. In order to achieve these, focus is placed on diversification of agricultural production and development of energy resources.

### 2. Hydropower Development in Nepal

Although Nepal has little coal, oil or natural gas resources, it is blessed with an estimated 28,000 MW of hydropower potential.

However, to date only 239 MW, or 1%, of the above hydropower potential has been developed due to financial and engineering constraints. In addition, the electrification rate of the country is a low 8%. Furthermore, 76% of energy consumption relies on firewood, a situation contributing to devastation of forest cover.

A major reason that Nepal has to this point been unable to fully realize its hydropower potential has been an over emphasis in the past on large scale development schemes which both in terms of financing and engineering aspects are by nature difficult to implement. To rectify this, the HMGN has recently shifted focus to:

① Immediate development of small~medium scale projects
② Encouragement of private sector investment in hydropower development

### 3. Priority of Ilam Small Hydropower Development Project

The envisioned Ilam Small Hydropower Development Project is well compatible with the above described emphasis by the Nepalese government on smaller scale hydropower schemes.

The bulk of the hydropower generating plants which form the mainstay of Nepal's generating capacity are concentrated in the Central and Western divisions. Even with electrification of the Ilam area, it is at the terminus of the power network and thus would still constitute an area most susceptible to the effects of power shortage. Given the fact that to alleviate the current power shortage situation, 6 MW of power is being imported from Kataiya substation in India for emergency supply independent of the national grid to Dharan and Dhankuta in the Kosi Zone, it is necessary to distribute power sources in a balanced manner by region. In this light, the Ilam Small Hydropower Development Project to establish a power source at the extreme eastern part of the Eastern Zone is highly significant from the standpoint of stable power supply.

It is extremely difficult to objectively rank areas in terms of priority for electrification. Nevertheless, Ilam is a major production area for tea and spice (cardamom), as well as a major area of dairy farming activity. Commercial exchange with India via Pasupatinagar is active as well. Although Pasupatinagar is not a district capital it is nevertheless a very important settlement in the area and is specially fed with power from the Gorke hydropower station

From the following standpoints, it is clear that Ilam is an important area to be developed for Nepal as a whole.

## 5.2 Salient Features of the Project

The following salient features of the Project are determined on the basis of optimum scale selection for the diversion site, power house site, and intervening headrace and penstock route determined as the most appropriate for the envisioned power development.

Diversion water level at the intake site on the Puwa khola is determined at EL 759.0. Diverted discharge is to be conveyed along an about 3.3 km headrace tunnel and then through an about 1.0 km penstock to the power house. Tailwater is discharged into the Mai khola at tailwater level of EL 436.7.

Salient features for the scheme are as follows:

(1) Catchment area : 125.1 km²

(2) Scheme type : run-of-river

(3) Intake weir

| | | |
|---|---|---|
| Type | : | natural overflow concrete dam |
| Intake method | : | Tyrolean type (intake channel: W 1.0 m, H. 0.75~2.0 m, L 16.5 m) |
| Weir height | : | 4.0 m |
| Weir length | : | 33.0 m |
| Overflow crest elevation | : | EL 759.0 |

(4) Headrace

| | | |
|---|---|---|
| Settling basin | : | standard inner section: H 5.0m, H 3.5 m, fan shaped, L 56.0 m |
| Headrace tunnel | : | standard inner section (horseshoe): upper semi circular radius 1.0m, lower section W 2.0 and H 1 m, L 3,200 m |
| Head tank | : | W 5.0 m, H 2.0~7.5 m, L 32.5 m |
| Spillway | : | inner section (horseshoe): upper semi circular radius 1.0 m, lower section W 2.0 m and H 1 m |
| Regulating pond | : | effective capacity: 2,000 $m^3$<br>water depth: 2.4 m<br>surface area: 925 $m^2$ |
| Penstock | : | steel, 1.10~0.60 m radius, L 990 m |
| Tailrace | : | inner section: W 2.0 m, H 2.0 m, L 30 m |

(5) Power house and electro-mechanical equipment

| | | |
|---|---|---|
| Power house | : | single floor type, 395 m², RCC made |
| Turbine | : | horizontal axis Pelton - 2 units<br>output : 2 × 3,300 kW<br>effective head : 304 m<br>maximum discharge : 2 × 1.25 m³/s |
| Generator | : | horizontal axis, 3 phase, synchronous - 2 units<br>capacity : 2 × 3,700 KVA<br>voltage : 11 kV<br>electric current : 194 A<br>power factor : 0.85<br>frequency : 50 Hz |
| Transformer | : | outdoor, 3 phase, oil cooled type - 2 units<br>capacity : 2 × 3,700 KVA<br>voltage : 11/33 ± 5% KV |
| Transmission line | : | pole suspension type : 33 KV × 1circuit<br>length to Ilam substation : 4.7 km |

## 5. Implementation Schedule

The Project features use of high head, with regulating capacity a relatively small 2,000 $m^3$. The headrace tunnel is however comparatively long at 3,200 m. Accordingly, the construction of the headrace tunnel is the critical path governing the overall construction schedule. Under the most effective construction plan for the said tunnel, maximum length of excavation sector is 2,133 m.

Period of construction required for this maximum sector length is 2 years, and the overall construction schedule has been formulated around this constraint.

## 6. Project Economic Viability

The economic viability of the Project is good as indicated by the following indices:

(a) Economic Internal Rate of Return (EIRR):

EIRR with diesel as the alternative generating facility is 19.70%

(b) Financial Internal Rate of Return (FIRR):

Based on the current average electricity tariff in effect in Nepal (Rs 2.27/kWH), FIRR is10.65%.

## 7. Secondary Development Effect

(1) Job Opportunity Effect and Development Effect on Related Industries

During the construction period, local labour employed for the construction are estimated at 350,000 man days of unskilled labor and 500,000 man days of skilled labour. Increased labour opportunities are also expected related to procurement, transportation, storage, custody, etc. of the many materials and equipment to be transported to the site. At the same time, the implementation of this Project contributes to development of industries in such sectors as procurement, transportation and storage of the above materials and equipment.

(2) Development Effect on Local District

In case this Project is implemented, roads infrastructure will not only be strengthened through improvement of existing roads, construction of new access roads, etc. but also the economy of Ilam district will be invigorated by procurement of a portion of construction materials within the district, and by consumption expenditure by workers related to the construction who stay in the district during the construction period.

## 8. Social and Environmental Impact

Size of regulating pond under the Project is small, and required compensation and or resettlement for the 2 $km^2$ occupied by facilities (including penstock, access roads, etc.) is not anticipated to pose any significant problems.

Field survey has indicated that the ground in the area is of such topographical and geological structure that construction of facilities under the Project will not pose the threat of landslide.

Although small scale diversion for irrigation is currently being performed on the Puwa khola, this diversion is done from May onwards when river discharge is ample, and is not anticipated to be adversely impacted by the implementation of the Project.

Also, there is an irrigation scheme planned for the slope on the Mai khola side; however, discharge in excess of the design discharge of 2.5 $m^3/s$ during the rainy season will be available for overflow from the head tank under the Project to feed irrigation water to nearby farm land.

**Conclusions**

(1) The Project site features good topography, geology and hydrology for hydropower development. Furthermore, access road conditions and availability of labour are favorable, making the Project of high economic viability.

(2) The Project features high head despite a relatively small design discharge, another factor making the envisioned hydropower development of superior economic feasibility.

(3) Geologic conditions at the head tank site are good. Tunnel excavation as well is not anticipated to encounter problems. Overall, engineering constraints do not affect the Project.

(4) On the basis of power forecast to date, the Project should go on line no later than March 1998.

(5) In order to realize the Project, a 4 year period in necessary to include arrangements for Project financing, detailed design, preparation of tender documents, tendering, contract finalization with contractors, preparatory works, main construction works, and trial operation.

(6) Under the 7th Power Project, a 33 kV transmission line is to be constructed into the Ilam area to connect it with the national grid by 1997. As a result, any surplus power produced under the Project can effectively be fed to the national grid.

**Recommendations**

(1) The Ilam Small Hydropower Development Project is advantageous in terms of economic aspects when compared with alternative power source. Although scale is small, 4 years will be needed to realize the Project. Accordingly, it is recommended that the executing agency, NEA, proceed in a timely manner in accordance with the implementation plan set out in this report to expedite the various administrative and other procedures necessary to ensure that the Project can go on line by March 1998.

(2) The Project is anticipated to have negligible minus impact on the regional socio-economy. However, land acquisition for the penstock, headrace site, etc. as well as camp site and construction areas will require the resettlement of 2~3 households. Host areas for resettlement, etc. must be carefully studied.

(3) Construction of irrigation and drainage facilities by the related irrigation agency is necessary to accommodate the excess discharge over the design discharge of 2.5 $m^3/s$ under the Project available for irrigation from the start of the rainy season of each year (May) to the farmland on the Mai khola slope within the Project area.

(4) In order to carry out more precise survey and study during the detailed design stage for the Project, it is important to continue the discharge gauging currently in progress for the Puwa and particularly the Mai kholas in order to supplement lacking data.

## COMPOSITION OF REPORT

| | | |
|---|---|---|
| VOLUME 1: | FINAL REPORT | |
| VOLUME 2: | FINAL REPORT (ANNEX) | |
| | ANNEX-I | TOPOGRAPHY AND GEOLOGY |
| | ANNEX-II | FLOW ANALYSIS (HYDROLOGY) |
| | ANNEX-III | CIVIL WORKS |
| | ANNEX-IV | POWER FLOW AND TRANSMISSION LINE |

## TABLE OF CONTENTS

## Chapter 7 Project Cost Estimation



## Chapter 8 Evaluation of the Project

## Chapter 9 Attached Drawings

Drawing List (1): Fig. 2.2-1 ~ Fig. 2.2-3

Drawing List (2): Fig. 2.3-1 ~ Fig. 2.3-6

Drawing List (3): Fig. 2.4-1

Drawing List (4): Fig. 3.6-1 ~ Fig. 3.6-15

Drawing List (5): Fig. 3.7-1 ~ Fig. 3.7-9

Drawing List (6): Fig. 4-1 ~ Fig. 4-2

Drawing List (7): DWG. No. ILAM-F/S001 ~ DWG. No. ILAM-F/S009

Drawing List (8): Fig. 5.5-1 ~ Fig. 5.5-6

## ABBREVIATIONS

| | | |
|---|---|---|
| JICA | : | Japan International Cooperation Agency |
| HMGN | : | His Majesty's Government of Nepal |
| NEA | : | Nepal Electricity Authority |
| MWR | : | Ministry of Water Resources |
| WECS | : | Water and Energy Commission Secretariat |
| CDO | : | Chief District Officer |
| | | |
| ADB | : | Asian Development Bank |
| OECF | : | Overseas Economic Cooperation Fund |
| GTZ | : | German Technical Assistance |
| CIDA | : | Canadian International Development Association |
| IDA | : | International Development Association |
| VDC | : | Village Development Committee |
| BPC | : | Butwal Power Company |
| | | |
| GNP | : | Gross National Product |
| GDP | : | Gross Domestic Product |
| FOB | : | Freight on board |
| CIF: | : | Cost, insurance and freight |
| FY | : | Fiscal year |
| O/M | : | Operation and maintenance |
| T/G | : | Turbine and generator |
| US$ | : | United States dollar |
| Rs | : | Nepalese rupee |
| ¥ | : | Japanese yen |
| FC | : | Foreign currency |
| LC | : | Local currency |
| EL | : | Elevation in meters above sea level |
| WL | : | Water level |
| FWL | : | Flood water level |
| CA | : | Catchment area |
| ACSR | : | Aluminum conductor steel reinforced |
| ha | : | Hectare |
| $m^3$/sec | : | Cubic meters per second |
| $m^3$/hr | : | Cubic meters per hour |
| t | : | Metric ton |
| °C | : | Degree centigrade |
| ° | : | Degree |
| $\phi$ | : | Diameter |
| TOE | : | Tons of coal equivalent |
| rpm | : | Revolutions per minute |
| Hz | : | Hertz (cycles per second) |
| kcal | : | Kilo calorie |
| kWh | : | Kilowatt hour |
| MWh | : | Megawatt hour |
| GWh | : | Gigawatt hour |

# CHAPTER 1

# CHAPTER 1 INTRODUCTION

## 1.1 General

Ilam district, which encompasses the Project area, is located in extreme eastern Nepal adjacent to the border with India. Administratively, it is within Mechi Zone of the Eastern Development Region. The Nepalese government originally planned to provide power to the eastern part of Nepal under the large scale Arun 3 hydropower scheme. However, difficulties in arranging financing for construction of the project has resulted in delay in its implementation. Although negotiations are now in progress for implementation of the access road construction plan (190 km) for the project, Arun 3 is not anticipated to be completed for at least another decade. The need has thus become acute to construct small scale hydropower schemes in the eastern region to cover power demand until such time as Arun 3 can go on line. Such small scale hydropower schemes have the advantage of short construction period. Against this background, HMGN in April 1992 requested cooperation from the Japanese government in the execution of the Feasibility Study for the Ilam Small Hydropower Development Project. The Japanese government subsequently agreed to carry out the said study under its technical cooperation program, and dispatched under JICA a preliminary study mission to Nepal from December 13, 1992 (for 12 days) to confirm the required scope of works for the study.

The preliminary study mission carried out a reconnaissance of the Project area, and consulted with the concerned officials of NEA and other related agencies. On the basis of the preliminary study mission findings, NEA, the executing agency for the Project, and JICA entered into agreement regarding the Scope of Work for the Feasibility Study for Ilam Small Hydropower Development Project on December 22, 1992.

On the basis of the foregoing Scope of Work, JICA contracted the engineering consulting firm Chuo Kaihatsu Corporation to carry out the Study works. (The consultant contract for Study works in FY 1992 was signed on February 19, 1993 and that for works in FY 1993 was signed on April 30, 1993.). The Study Team accordingly was fielded from February 21, 1993.

## 1.2 Study Description

### 1.2.1 Study Objectives

The objectives of the Study are to formulate the optimum development plan for the Ilam Small Hydropower Development Project on the basis of technical, economic, financial and environmental criteria, and prepare and submit a feasibility study report for the said optimum development plan. During the course of the Study, feasibility study technology is to be transferred as well to Nepalese counterparts.

### 1.2.2 Study Period and Study Components

According to the Scope of Works, the Study is to be completed within one year from commencement in March 1993 (or within 2 months of receiving comments from NEA on the Draft Final Report to be submitted within 9 months of the commencement of the Study). The contract for services accordingly signed between JICA and Chuo Kaihatsu Corporation comprised the following:

| | | |
|---|---|---|
| FY 1992 | : | Contract signed February 19, 1993 |
| Period | : | From February 21, 1993 to March 31, 1993 |
| Study content | : | Identification Stage comprising the following components |

Identification Stage

(1) Data collection

a) Meteorological data
b) Hydrological data
c) Topo maps
d) Geological data
e) Power demand related data
f) Regional socio-economy related data

(2) Power situation study

a) Survey of existing power and transmission facilities, and the status of their operation
b) Study of power demand growth rate and characteristics
c) Study and forecast for power demand and peak power from 1982 to 2005
d) Study and analysis of existing electrification planning

(3) Field Survey

a) Surface reconnaissance (including access road route) of topography and geology at the Project site
b) Preliminary hydrological survey
c) Preliminary survey of social and natural environment

(4) Site Selection Survey

a) Formulation of alternatives for the project taking into consideration integrated development of the Puwa khola catchment
b) Site selection on the basis of technical, economic and environmental criteria
c) Preparation of base plan

d) Selection of design electrification area

(5) Preparation of schedule for topographical and geological survey to be performed during the Field Investigation Stage

FY 1993 : Contract signed April 30, 1993
Period : From April 30, 1993 to February 28, 1994
Study content : Two stages including Field Investigation Stage and Feasibility Design Stage

Field Investigation Stage

(1) Topographical survey

a) Topographical survey and preparation of topographical maps for intake site, headrace canal alignment, headtank site, penstock alignment and power house site

(2) Geological survey

a) Test drilling and permeability testing at sites for major structures
b) Elastic wave prospecting at sites for major structures
c) Test pit and adit excavation (where necessary)
d) In situ and laboratory testing
e) Preparation of geological map of the entire project area, and geological profiles for headrace and penstock alignments

(3) Hydrological survey

a) Survey and observation of rainfall, discharge and suspended load
b) River runoff survey, meteorological analysis and sedimentation estimate

(4) Survey of present status of regional electrification

(5) Environmental impact assessment

Feasibility Design Stage

(1) Formulation of alternatives for power house, transmission line, and substation facilities

(2) Comparative study of alternatives and selection of optimum plan

(3) Preliminary design

(4) Project costing

(5) Preparation of Project construction schedule

(6) Economic analysis

(7) Financial analysis

(8) Environmental impact assessment

### 1.2.3 Study Area

The Study area encompasses the Puwa and Mai kholas in Ilam district, and their related rivers, tributaries and catchment areas.

### 1.2.4 Study Participants

Members of the JICA Study Team and the Nepalese Counterparts who participated in the subject Feasibility Study are as follows:

| Position | Name | Organization |
|---|---|---|
| **JICA Study Team** | | |
| Team Leader | H. Sugiyama | Chuo Kaihatsu Corporation |
| Hydropower Civil Engineer | Y. Fujii | Chuo Kaihatsu Corporation |
| Hydrologist | S. Kimura | Chuo Kaihatsu Corporation |
| Topographical Survey Engineer | Y. Kamada | Asahi Koyo Corporation |
| Geologist | Y. Tonogami | Geotech, Ltd. |
| Generating Facilities and Demand Forecast Engineer | H. Yamada | Chuo Kaihatsu Corporation |
| Transmission System Analysis Engineer | M. Sasaki | Chuo Kaihatsu Corporation |
| Economist | K. Satoh | Chuo Kaihatsu Corporation |
| Environmentalist | N. Mochizuki | Taiyo Consultants |
| **NEA Counterparts** | | |
| Coordinator / Hydropower Civil Engineer | B. K. Manandhar | NEA |
| Economist / Environmentalist | Dr. M. D. Joshi | NEA |
| Electrical Engineer | R. R. Shrestha | NEA |
| Geologist | K. M. Nepal | NEA |

# CHAPTER 2

# CHAPTER 2 PROJECT BACKGROUND AND RATIONALE

## 2.1 National and Regional Background

### 2.1.1 The Land and the People

Nepal is a mountainous country located in subtropical zone. It lies along the middle 800 km of the 2,500 km Himalayan range running east~west. The average breadth of the country north~south is 200 km. Elevation in the country drops rapidly from the Tibetan highlands over 5,000 m to the Hindustan plain at 150 m above sea level. This represents a roughly 5,000 m change in elevation over a horizontal distance of only 200 km. Consequently, rapidly flowing rivers with steep gradient have deeply cut the landscape. The Great Himalayan range rises like a giant wall slightly to the south of the Tibetan highlands, its slopes carved into sharp relief by rapidly coursing rivers. This dissection is largely in the form of preformed deep gorges running north~south. The major north~south river systems in the country are, starting with the most easterly, the Kosi, Gandaki and Karnali systems, all of which have their headwaters in the Tibetan highlands, and finally empty into the Ganges river to the south.

Nepal land area is 141,000 km$^2$, of which 83% is mountain and hill area. North to south, the country can be broadly classified into 3 zones: (i) the mountain zone in the north with elevation in excess of 5,000 m featuring over 240 peaks with elevation of 6,000 m or more, major among which are some of the highest peaks in the world: Sagarmatha (Everest: 8,848 m), Kanchanjunga (8,586 m), Manasuru (8,163 m), Annapurna (8,091 m), Dhaulagiri (8,167 m), etc., (ii) the hill zone at elevation of 600~5,000 m including the Kathmandu and Pokara valleys, which is the location of settlements including towns and villages, as well as terrace farming on hill sides, and (iii) the Hindustan plain (known as the "Terai") in the far south at elevation of 150 m above sea level which is the major grain producing area in Nepal.

Breakdown of type of land in 1985 is as follows:

| | |
|---|---|
| Cultivated land | 22% |
| Forest | 27% |
| Grazing land | 12% |
| Mountain area | 14% |
| Wasteland | 21% |
| River, lakes, buildings, roads | 4% |

A serious problem in the breakdown of type of land is a sharp drop in forested and grazing land, and reverse sharp increase in wasteland.

The population of Nepal comprises a mosaic of ethnic groups with differing cultures and languages. Population growth trend in recent years is indicated below:

| 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|
| 17,591,000 | 17,976,000 (+2.2%) | 18,438,000 (+2.5%) | 19,096,000 (+3.5%) |

Roughly 56% of the population resides in the mountain and hill areas of the country. Nevertheless, there has been a trend of population migration from the mountain and hill areas to the Terai plain, with population increase in the Terai plain being 4.3% per year in comparison with 1.4% and 1.7% for the mountain and hill areas, respectively. According to a World Bank prediction, average population growth rate per annum for the country as a whole until the year 2000 is estimated at 2.5%.

### 2.1.2 GNP

GNP growth trend in recent years is indicated below:

| | 1987 | 1988 | 1989 | 1990 |
|---|---|---|---|---|
| Total GNP (US$) | 2,843,000,000 | 3,128,000,000 | 3,202,000,000 | 3,289,000,000 |
| Per capita GNP (US$) | 160 | 170 | 170 | 170 |

Roughly 94% of the population live in rural villages. By sector, agriculture (including animal herding and fishery) accounts for 50% of the nation's GNP. Industry as well has been traditionally agricultural related: oil extraction, food processing, etc. Agricultural products accounted for over 60% of all export earnings in 1983~84.

In 1984, agriculture accounted for 62% of total GDP, with mining and the service industries accounting for 12% and 26%, respectively. Presently as well, the economy of the country remains heavily dependent on agriculture. Principal sources of foreign exchange earnings are exports of rice and jute, as well as tourism and assistance from abroad. On occasion, foreign assistance has accounted for approximately 50% of the national budget, with the majority of said budget being earmarked for national development.

### 2.1.3 Trade

The trade deficit of the country has grown rapidly in recent years due to (i) lack of growth in exports due to lack of product competitiveness on the international market, and (ii) heavy reliance on imports for items ranging from products for every day use to materials and equipment necessary for development projects.

In previous years, HMG had been able to offset its trade deficit through income from the tourist sector, remittances home and pensions of Gurka soldiers serving in the Indian and British armies, as well as grant assistance from abroad. However, since the beginning of the 1980's, the current account balance has been in the red with year-wise deficits as indicated below.

unit: Rs 1 million

| | Exports (FOB) | Imports (CIF) | Deficit |
|---|---|---|---|
| 1982/83 | 1,132.0 | 6,313.9 | -5,181.9 |
| 1983/84 | 1,703.9 | 6,514.3 | -4,810.4 |
| 1984/85 | 2,740.6 | 7,742.1 | -5001.5 |
| 1985/86 | 3,078.0 | 9,341.2 | -6,263.2 |
| 1986/87 | 2,991.4 | 10,905.2 | -7,913.8 |

Principal products imported and exported during 1986/87 are as follows:

(imports)

| | |
|---|---|
| Manufactured goods | 29.6% |
| Machinery and transportation equipment | 25.5% |
| Chemicals, pharmaceuticals | 11.8% |
| Food products (animal) | 9.4% |
| Fossil fuels | 8.5% |
| Others | 15.2% |

(exports)

| | |
|---|---|
| Manufactured goods | 38.8% |
| Food products (animal) | 23.5% |
| Mineral ore | 16.4% |
| Others | 21.3% |

### 2.1.4 Labour Situation

According to the population census of 1981, 84.9% of total households nationwide of 2,590,000 are engaged in agriculture for a livelihood (this includes both stock farming and fishery). The agricultural sector accounts for 79% of the employed labor force (males and females between the ages of 10~50 comprise 52% of the total population of the country). In rural villages, children constitute an important segment of the labor force, performing such tasks as livestock tending, water fetching and fire wood collection. As the children grow older and their skills increase, they become even more irreplaceable from the standpoint of required village labour.

At present, labour standards legislation is in effect in Nepal, under which labour wages are stipulated as follows:

1. Minimum wages are stipulated as per below:

| | | |
|---|---|---|
| A. | 14~16 yrs old | Rs 800 / mo. |
| B. | Unskilled labourer | Rs 1,000 / mo. |
| C. | Semi-skilled labourer | Rs 1,050 /mo. |
| D. | Skilled labourer | Rs 1,160 /mo. |
| E. | Highly skilled labourer | Rs 1,350 /mo. |

(However, when computing salaries on a daily wage basis, Rs 150 / mo. must be added to each of the figures above.)

2. With regards to labor hours, persons in category (A) above may work no more than 6 hours per day. For categories (B)~(E), labour hours must be no more than 12 per day. Normal working hours are 10:00~17:00 in the case of civil servants, and 9:00~17:00 in the private sector.

3. Determination as to what category of skilled or unskilled labour a potential employee falls into is made by the employer.

4. Further to item 1 above, minimum daily wages are stipulated as follows:

| | | |
|---|---|---|
| ① | under 14 years old | Rs 30/day |
| ② | 14 years or older (both male and female | Rs 40/day |

(source: Ministry of Labour, KTM)

Individual districts as well announce annually through the Chief District Officer, standard wages determined for that local.

Such standard wages for Ilam district for FY 1991 / 1992 are as follows:

| | |
|---|---|
| Unskilled labourer | Rs 7 / hr. |
| Semi-skilled labourer | Rs 10 / hr. |
| Skilled labourer | Rs 12 / hr. |
| Average | Rs 11 / hr. |

Labour law in Nepal also stipulates that a contract must be established between employer and employee where the latter is to be employed for over 2 weeks, and that under said contract, the employer must inform the employee at least 2 weeks in advance prior to any release from employment.

### 2.1.5 Agricultural Production

According to statistics for FY 1985/86 (the fiscal year in Nepal extends from July 16 to July 15 of the following year), the agricultural sector accounted for 57.1 % of the total GDP, underscoring the fact that development of the agricultural sector will be a key to overall development of the nation's economy. Nevertheless, growth within the agricultural sector remains unsatisfactory. The depressed growth in food production is particularly serious. With improvements in health and sanitation, and wider availability of medical services, the mortality rate in Nepal has declined with a proportionate increase in population with which food production has been unable to keep pace. Nepal was a net exporter of rice until the late 1970's. However, the poor harvest in 1982 induced serious food shortage in the country, prompting the prohibition of rice and maize exports and the need to rely on food assistance from abroad.

The following constraints are seen as impeding increased production within the agricultural sector:

1) Further extension of cultivable land has virtually reached its limit given the rugged topography of the country.

2) The increase in cultivation of jute, sugar cane, oil seed, tobacco, vegetables and other cash crops threaten the available area for cultivation of food grains.

3) Population increase has resulted in unmanaged development of unsettled areas, resulting in the creation of wasteland areas impacting adversely on overall farm production potential.

4) There are no countermeasures in place for drought and other climatic factors affecting agricultural production.

Export of rice was resumed in FY 1983 / 84 with the surplus production of 190,000 tons of paddy. However, production and consumption of domestic rice is heavily skewed by region, with surplus rice produced in the Terai plain being exported southward across the free border into India rather than north into the hill areas which are very weak markets (very low purchasing power) due to fragile economic base.

### 2.1.6 Energy Situation

The consumption structure for energy in Nepal in FY 1990/91 is indicated in the table below. Fuelwood accounts for 76% of consumed energy amount, while electrical power accounts for only 0.83%.

**Structure of Energy Consumption**

('000 tons of coal equivalent)

| Energy Sources | 1979/80 | 1980/81 | 1981/82 | 1982/83 | 1983/84 | 1984/85 | 1985/86 | 1986/87 | 1987/88 | 1988/89 | 1989/90 | 1990/91* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Traditional | | | | | | | | | | | | |
| Fuel wood | 4340.8 | 4476.4 | 4595.5 | 4717.7 | 4946.0 | 5075.0 | 6248.0 | 6393.0 | 6544.0 | 6667.0 | 6786.0 | 6806.0 |
| Agri. waste | 77.1 | 79.2 | 81.3 | 83.4 | 550.0 | 565.0 | 893.0 | 944.0 | 961.0 | 967.0 | 989.0 | 992.0 |
| Animal dung | 29.2 | 30.0 | 30.8 | 31.6 | 95.0 | 98.0 | 696.0 | 710.0 | 725.0 | 737.0 | 748.0 | 750.0 |
| Commercial | | | | | | | | | | | | |
| Petroleum | 157.9 | 174.4 | 164.5 | 176.7 | 210.5 | 229.9 | 268.0 | 288.0 | 330.0 | 301.0 | 266.0 | 207.0 |
| Coal | 31.4 | 32.3 | 35.3 | 36.3 | 86.4 | 69.1 | 46.0 | 74.0 | 76.0 | 70.0 | 21.0 | 107.0 |
| Electricity | 19.9 | 20.2 | 22.7 | 27.3 | 30.3 | 35.5 | 39.0 | 50.0 | 52.0 | 58.0 | 67.0 | 74.0 |
| Total | 4656.3 | 4812.5 | 4930.1 | 5073.0 | 5918.2 | 6072.5 | 8190.0 | 8459.0 | 8688.0 | 8800.0 | 8877.0 | 8936.0 |

*estimated
source: Water and Energy Commission

Energy consumption in the country as a whole has grown 85.7% in 10 years. However, considering the fact that energy consumption rates in terms of fuel wood and electricity in FY 1980/81 were 93% and 4.2%, respectively, it can be concluded that there has been no tangible improvement to the present in the energy source structure. From the standpoint of destruction of the natural ecology due to tree felling for fuel wood, the further development of hydropower resources, which are present in abundance as well as being environmentally clean, as an alternative energy source is concluded to be an urgent issue. Furthermore, the wider availability of electrical power is needless to say essential for modernization of the nation's socio-economy.

### 2.1.7 National and Regional Development Planning

As discussed earlier, Nepal can be broadly classified in terms of topography and ecology into 3 general physical regions: mountain region, hill region and Terai plain region. Development strategies have been formulated by HMGN based on the special characteristics of each region. Furthermore, in order to achieve balanced development of the country as a whole the nation has been administratively divided east to west (along zones and district boundaries) into 5 development regions. These development regions are as follows:

① Eastern Development Region (containing 3 divisions and 16 districts, including Ilam)

area: 28,456 km²
population: 3,708,923

② Central Development Region (containing 3 divisions and 19 districts, including the capital of Kathmandu)

area: 27,410 km²
population: 4,909,357

③ Western Development Region (containing 3 divisions and 16 districts)

area: 29,398 km²

population: 3,128,859

④ Middle Western Development Region (containing 3 divisions and 15 districts)

area: 42,378 km²
population: 1,955,611

⑤ Far Western Development Region (containing 2 divisions and 9 districts)

area: 19,539 km²
population: 1,320,189

The Government has pursued economic development under a series of 5 year national plans. The first national plan was inaugurated in 1956, at which time social and economic infrastructure existed only in limited areas of the Katmandu valley and the vicinity of the border with India. Accordingly, emphasis was placed on the establishment of road, telecommunications, power generating / transmission , and irrigation facilities.

To unite the country politically, the monarchy was restored in 1951. Both politically and economically, the transportation and telecommunications sectors played a vital role in the unification of the nation.

Achievements in terms of GDP growth rate under each of the five year national plans since the third are indicated below:

| | | Agricultural sector (%) | Non-agricultural sector (%) | Total (%) |
|---|---|---|---|---|
| 3rd national plan | (65/66~69/70) | 2.9 | 2.4 | 2.7 |
| 4th national plan | (70/71~74/75) | 1.5 | 2.2 | 1.8 |
| 5th national plan | (75/76~79/80) | Δ1.1 | 7.3 | 2.3 |
| 6th national plan | (80/81~84/85) | 4.3 | 4.0 | 4.2 |
| 7th national plan | (85/86~89/90) | 5.7* | 3.0* | 4.6* |
| | | (3.5) | (5.7) | (4.5) |
| 8th national plan | (91/92~96/97) | (3.7) | (6.1) | (5.1) |

* = estimated figure ( ) = planned figure

Development planning experienced a turning point under the 4th national plan. By the 4th national plan it became evident that intended economic growth was not being realized due to the fact that the number of uncompleted projects carried over from previous plans was steadily increasing, placing an excessive financial burden on HMGN. Furthermore, structural factors were suppressing benefit received from investment including (i) obstacles to procurement of equipment and materials for development stemming from failure to sign a trade and commerce agreement with neighboring India, (ii) the armed conflict between India and Pakistan and the war for independence in Bangladesh (then East Pakistan), (iii) external factors such as worldwide inflation, and (iv) cost escalation for economic development stemming from the general geographical remoteness of the country.

Accordingly, the 5th National Plan shifted from emphasis on transportation and communications infrastructure to placing emphasis on direct and efficient investment in production, particularly in the agricultural sector where there was a perceived need to increase farm productivity. At the same time, the number of development regions was expanded from 4 to 5 in 1980, for more finely tuned economic development planning by area. Unfortunately, this approach in effect was constrained by existing factors and was unable to produce tangible results. Due to ability to more effectively absorb development investment due to existing levels of economic and social infrastructure, areas such as the Terai, although already relatively more developed than remoter regions, were given greater emphasis.

Under the 7th National Plan, despite emphasis in both the agricultural and non-agricultural sectors, growth rates remained at a low level as indicated in the previous table. The subsequent 8th national plan likewise focuses on development in both the agricultural and non-agricultural sectors.

Under the 8th national plan (FY 1991/92~ FY 1996/97), annual production growth rates targeted for agriculture are 5.4% for grains, 8.4% for legumes, 9.1% for various cash crops, 5.4% for horticultural crops, 3.8 for livestock, and 12.0% for fisheries.

Total investment under the 8th National Plan is Rs 170,332,000,000 (as compared to Rs 103,014,000,000 under the 7th National Plan). Breakdown of investment amounts for the top 3 sectors are: Rs 43,876,000,000 for the agriculture/irrigation/forestry sector (25.8%), Rs 33,184,000,000 for the finance/realty sector (19.5%), and Rs 27,668,000,000 for the power/gas/water service sector (16.2%). Investment allocation specifically for power development is Rs 23,719,000,000.

The 8th National Plan sets forth in its energy development objectives to establish hydropower as a main power source. Within this framework, sub targets are to (i) to undertake various scales of hydro power development projects, (ii) to provide inexpensive energy for industrial and irrigation activities during off peak hours through the expansion and proliferation of hydropower generating facilities, and (iii) steadily decrease dependence on fuel wood, fossil fuels and imported energy to the extent practical. The 8th National Plan envisions over its 5 year duration the construction of 29,700 kW of additional power generating capacity and 405 km of transmission line.

## 2.2 Power Situation

### 2.2.1 General

Situated along the middle of the Himalayan range, Nepal has abundant water resources with an estimated 28,000 MW of economically viable hydropower potential. Of this, only 230 MW (or 1%) has been developed to date. Furthermore, electrification of the country remains at a low 8%. One reason for this is that 80% of the country's land area comprises rugged hill and mountain area with undeveloped road infrastructure making extension of the power grid difficult.

A 132 kV transmission line and appurtenant facilities extend east~west through the Terai plain in the south, and a power grid connects the major population centers of Kathmandu, Pokhara, Hetauda, etc.. The major medium to large size power generating stations are connected to the foregoing facilities, but electrification remains limited to only those areas effectively within reach of the grid. As a result, the district capitals located in the more isolated hill areas must rely on independent hydropower sources which service only the capitals and their immediate surrounding areas. Of the total 75 district capitals in the country, 7 remain unelectrified as of 1992. Apart from district capitals, small scale independent power generating systems have been constructed to provide power to lodging facilities along popular trekking routes.

### 2.2.2 Recent Power Situation

Under the ADB funded Sixth Power Project, the national power grid was expanded and appurtenant distribution facilities established, with concomitant growth in power demand. However, large scale hydropower schemes such as Arun III (402 MW) and Kali-Gandaki (140 MW) have not been implemented as scheduled. Furthermore, ponding has not been successful at Kulekhani No. 1, the sole dam type hydropower scheme in Nepal. As a result of these and other factors, the 1992-1993 winter experienced a severe power shortage, with blackouts imposed between 17:00 and 20:00 in the evening, and from 23:30 to 9:00 the following morning.

The above type of imposed blackout original were begun in March 1992, being temporarily suspended in mid June at the commencement of the rainy season. However, with the advent of the dry season in October 1992, the blackouts were again put into effect.

With the start of the rainy season in 1993, the power situation improved. However, shortly thereafter in late July, heavy rains washed out the penstock at Kulekhani No. 1 power station and swept away the intake at Kulekhani No. 2 as well, resulting in a net loss of generating capacity equal to 92 MW. As a result, forced cut off of power supply in Katmandu during 2 peak hours in the evening became necessary despite it being the rainy season. Restoration of the facilities at Kulekhani No.1 and 2 is reported to require at least a year, which is anticipated to cause severe power shortages from this year's dry season as well.

### 2.2.3 Power Situation in the Ilam Area

Ilam N.P., the district capital for Ilam, is serviced by a 200 kW diesel generating plant serving 340 consumers, with an additional 220 consumers having applied for power service. However, NEA has not been able to respond to these applications due to insufficient generating capacity. Power is supplied by the system during the four hour period 18:00 to 22:00; however, demand greatly outstrips generating output, due to a condition aggravated by the obsolete condition of equipment. Power output at the plant is around 300 V (250 V on extreme occasions) despite a rated voltage of 400 V. The generating and distribution facilities are operated and managed by NEA staff of 23 persons, incurring personnel costs of Rs 45,000/month. In contrast, power use fees collected from customers total only Rs 25,000/month. On top of this, fuel costs amount to Rs 45,000/month. This deficit is at present covered by Government subsidy, with the foregoing situation underscoring the difficulty in transport and expense entailed in supplying fuel to diesel plants in the Nepalese hill area.

Due to the restricted hours of power supply and the voltage drop which occurs in the Ilam diesel power system, energy is used solely for lighting with none available for industrial purposes. In the case of the Government run tea estates in the area, recourse is made to individually operated diesel generators.

### 2.2.4 Power Administrative and Operating Structure

Until recently, the Nepal Electricity Authority (NEA) assumed responsibility for the management of all power supply in the country. However, since 1992 private sector enterprises have engaged in power development and power system management, an example being the Butwal Power Company which operates the Andi khola hydropower station (5,100 kW) completed in 1991. The same corporation is currently constructing the Jhimruk hydropower station (12,000 kW) as well as being in the process of planning the Khimti khola hydropower station (60,000 kW).

NEA is under the jurisdiction of the Ministry of Water Resources, with policy decisions made by a board of directors headed by the Minister of Water Resources. Other members of the board of directors include deputy ministers of the ministries of National Planning, Justice, Finance, and Industry, assistant director of the Ministry of Water Resources, assistant director of the Rastra Bank, and the managing director of NEA. Decisions of the board of directors are executed by the NEA managing director. Under the NEA managing director are the 8 divisions of Distribution and Consumer Services, Construction, Engineering, Operation and Maintenance, Arun III Development, Regional Electrification, Planning, and Finance and Administration, each headed by a director-in-chief. (see Figure - 2.2-1, NEA Organization)

## 2.2.5 Energy Policy

HMGN is currently pursuing its Eighth National Plan (1993~1997), under which the 3 major targets are stable and sustained economic growth, alleviation of poverty and rectification of skewed levels of regional development. In order to achieve the foregoing, rural electrification and diversification of agriculture through development of energy resources are priority policies.

Nevertheless, power shortage remains severe despite abundant hydropower potential in the country, and this in turn puts a strong brake on industrial development. In this light, the development of highly cost effective hydropower is considered an extremely high priority issue under national planning in order to raise productivity in all sectors of economic activity.

In light of the fact that large scale power generating schemes will not come on line until after the year 2000, government policy has shifted to include the private sector in power development and management in addition to NEA, particularly with regards to the urgent need to implement small to medium sized hydropower schemes. NEA targets as well development of energy intensive industries domestically, as well as expansion of energy export to neighboring India. This includes priority ranking of promising hydropower sites by small, medium and large scale categories to encourage participation in the development of the same by both domestic and foreign enterprises.

## 2.2.6 Power Generating Capacity both Existing and Under Construction

Existing hydropower generating capacity in Nepal totals around 239 MW of output. Of this, 9 generating facilities are medium to large scale (over 2,000 kW), totaling 229 MW equivalent to 96% of total capacity. Small scale hydropower generating facilities (under 2,000 kW) comprise 35 schemes with total output of 10 MW. The majority of these are independent systems isolated from the national grid. (see Table 2.2-1 Existing Hydropower Stations)

**Table 2.2-1 Existing Hydropower Stations**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Major Hydro Project | | | | | | | |
| 1. | Panauti | 2,400 | kW | 13. | Jomsom | 240 | kW |
| 2. | Trisuli | 21,000 | " | 14. | Jumla | 200 | " |
| 3. | Sunkosi | 10,500 | " | | | | |
| 4. | Gandak | 15,000 | " | 15. | Dhading | 32 | " |
| 5. | Kulekhani No.1 | 60,000 | " | 16. | Syangja | 80 | " |
| 6. | Devighat | 14,100 | " | 17. | Seti (Pokhara) | 1,500 | " |
| 7. | Kulekhani No.2 | 32,000 | " | 18. | Helamvu | 50 | " |
| 8. | Marsyangdi | 69,000 | " | 19. | Darchula (I) & (II) | 300 | " |
| 9. | Andhi Khola (BPC) | 5,100 | | 20. | Salleri (Sceco) | 200 | " |
| | | 228,650 | kW | 21. | Chame | 45 | " |
| | | | | 22. | Taple Jung | 125 | " |
| | Small Hydro Project | | | 23. | Manang | 80 | " |
| 1. | Surnaiya (Baitadi) | 200 | kW | 24. | Chaurjhari | 150 | " |
| 2. | Sudarijal | 640 | " | 25. | Syarpudaha | 200 | " |
| 3. | Pokhara | 1,088 | " | 26. | Khadabari | 250 | " |
| 4. | Dhankuta | 240 | " | 27. | Terhathum | 100 | " |
| 5. | Tinau (Butwal) | 1,024 | " | 28. | Dhojpur | 250 | " |
| 6. | Surkhet (Jhupra) | 345 | " | 29. | Ramechhap | 75 | " |
| 7. | Gajuri | 25 | " | 30. | Ramechcap | 200 | " |
| 8. | Thansing | 20 | " | 31. | Bajura | 200 | " |
| 9. | Baglung | 175 | " | 32. | Arughat Gorkha | 150 | " |
| 10. | Doti | 200 | " | 33. | Tatopani Myagdi | 1,000 | " |
| 11. | Phidim | 240 | " | 34. | Okhalkhunga | 125 | " |
| 12. | Gorkhe | 64 | " | 35. | Rupal Gad Dadedhura | 100 | " |
| | | | | 36. | Mamche | 600 | |
| | | | | | | 10,513 | kW |

note: BPC = hydropower stations under the Butwal Power Company

Hydropower projects currently under construction are shown in Table 2.2-2. The Jhimruk facility is being constructed by the Butwal Power Company and is scheduled to start operation in 1995.

**Table 2.2-2 Hydropower Stations Under Construction**

| Major Hydropower Project | | Small Hydropower Projects | |
|---|---|---|---|
| Jhimruk (BPC) | 12,500 kw | Tatopani II | 1,000 kw |
| | | Acham | 400 kw |
| | | Kalikot | 500 kw |
| | | Dolpa | 160 kw |

Existing diesel generating capacity comprises 23 stations totaling 55 MW. Facilities with capacity over 500 kW are connected to the national grid, while those under 500 kW, as in the case with Ilam as discussed earlier, are isolated systems servicing only the immediate area. However, of the above mentioned capacity of 55 MW, 7 MW is non functional due to obsolete equipment. At present, there are no new diesel power stations under construction. (see Table 2.2-3 Existing Diesel Power Stations)

**Table 2.2-3 Existing Diesel Power Stations**

| | | In operation | Suspended operation |
|---|---|---|---|
| 1. | Mahendra Kathmandu | 1,728 kW | -- |
| 2. | Dharan | | 618 kW |
| 3. | Biratnagar | 1,028 kW | 1,500 kW |
| 4. | Patan (Lalitpur) | 1,490 kW | |
| 5. | Hetauda | 14,470 kW | -- |
| 6. | Janakpur | -- | 1,360 kW |
| 7. | Tansen | -- | 224 kW |
| 8. | Jareswar | -- | 172 kW |
| 9. | Bhadrapur | -- | 1,384 kW |
| 10. | Taulihawa | -- | 100 kW |
| 11. | Krishnanagar | -- | 112 kW |
| 12. | Napalgunj | -- | 553 kW |
| 13. | Ghorahi | -- | 112 kW |
| 14. | Malangwa | -- | 264 kW |
| 15. | Gaur | -- | 264 kW |
| 16. | Ilam | 200 kW | |
| 17. | Lahan | -- | 368 kW |
| 18. | Tulsipur | -- | 50 kW |
| 19. | Gulariya | -- | 224 kW |
| 20. | Dadeldhura | 112 kW | -- kW |
| 21. | Ambukhaireni | 2,250 kW | -- kW |
| 22. | Salyan | 100 kW | -- kW |
| 23. | Multi-Fuel (Morang) | 26,000 kW | -- kW |
| | | 47,378 kW | 7,305 KW |

In addition to the above, there are 3 solar power stations in Nepal with total capacity of 130 kw. A single wind power station exists with 20 kW capacity, however it is out of order at present.

Accordingly, total generating capacity in the country is 290 MW. Of the existing hydropower stations, Kulekhani No. 1 is the only dam type scheme. In addition, the only scheme with a regulating pond and thus capable of daily regulating of discharge is the Sun Kosi scheme. On the other hand, most diesel plants are outdated and 80% of power supply is dependent on hydropower, with most of this accounted for by simple run-of-river schemes. As a result, total output during winter peak load is no more than 200~210 MW.

## 2.2.7 Planned Hydropower Stations

Principal hydropower stations under planning are shown in Table 2.2-4 and Proposed Hydropower Projects.

**Table 2.2-4 Planned and Proposed Hydropower Projects**

| | | | |
|---|---|---|---|
| 1. | Budhi Gandaki | 600,000 | kW |
| 2. | Kali Gankaki No 2 | 60,000 | " |
| 3. | Kankai (Multipurpose) | 225,000 | " |
| 4. | Sapta Gandaki | 225,000 | " |
| 5. | Naumure | 200,000 | " |
| 6. | Lower Arun | 300,000 | " |
| 7. | Seti (West) | 285,000 | " |
| 8. | Arun3 | 402,000 | " |
| 9. | Bagmati | 140-210,000 | " |
| 10. | Kali Gankaki A | 140,000 | " |
| 11. | Tama Koshi No.2 | 123,000 | " |
| 12. | Bhote Koshi No.2 | 69,000 | " |
| 13. | Andhi Khola No.1(Reservoir) | 180,000 | " |
| 14. | Upper Arun | 380,000 | " |
| 15. | Khimti Khola | 60,000 | " |
| 16. | Seti Gandaki | 320,000 | " |
| 17. | Karnali (Chisapani) | 10,800,000 | " |
| 18. | Upper Karnali | 240,000 | " |
| 19. | Pancheshwar (Mahakali) | 1,000,000 | " |
| 20. | Puwa Khola | 6,200 | " |
| 21. | Modi Khola | 14,000 | kW |

With the exception of the Khimti khola (60 MW) scheme, for which planning is essentially completed and construction is scheduled to be finished by the Butwal Power Company in 1998, source of funding for the above projects remains unclear and accordingly their completion dates are largely uncertain as well. Exceptions are the Kali Gandaki (140 MW) scheme for which funding arrangements with ADB are beginning to take shape and completion is anticipated by 1999~2000 (detailed design is currently in progress by the JV of Morrison Knudson Engineering (USA), Norconsul (Norway) and IVO (Finland)), and Arun III for which half (201 MW) of originally planned capacity is targeted to go on line under World Bank funding by 2001~2003. Nevertheless, many unresolved issues with regards to funding share and amount by donor country still remain for this scheme as well.

In addition to the projects indicated in the table above, development of 38 small hydropower schemes (under 50 MW) has been opened up by the Ministry of Water Resources for participation by private enterprises.

### 2.2.8 Current Status of Transmission Line and Plans for Extension

Recently, a 132 kV transmission line has been extended from Marsyandi hydropower station, and 33 kV transmission lines have been extended into 9 areas under the ADB funded 6th Power Project. Total transmission line countrywide as of the present is as follows:

| | | |
|---|---|---|
| 132 kV | 1,191 km | (single circuit) |
| 66 kV | 158 km | (double circuit) |
| 66 kV | 64 km | (single circuit) |
| 33 kV | 1,196 km | (single circuit) |
| Total | 2,609 km | |

The above total length is equivalent to a low figure of only 3 times the entire countries length east~west of 800 km.

A further 220 km of 33 kV transmission line including from Dhulabari to Ilam N.P.(45 km) is to be completed under the 7th Power Project (originally targeted completion: 1996; anticipated completion: 1997). 11 kV distribution line is also planned for construction within the Ilam Bazar area under the foregoing plan. This means that Ilam N.P. and environs will be connected to the power grid as of 1997.
(see Fig. 2.2-2 Transmission Line in Nepal)

### 2.2.9 Current Status of Substation Facilities and Plans for Strengthening the Same

In addition to extension of transmission line, substation facilities have been strengthened as well under the Sixth Power Project. Current substation capacity countrywide is as follows:

| | |
|---|---|
| 132/11 kV | 28.5 MVA |
| 132/33 kV | 145 MVA |
| 132/66 kV | 102.8 MVA |
| 66/11 kV | 193.3 MVA |
| 66/33 kV | 12.5 MVA |
| 132/33/11 kV | 10 MVA |
| Total | 492.1 MVA |

Under the 7th Power Project, substation facilities at 8 locations will be expanded as well as a new 33/11 kV, 3 MVA facility constructed at Ilam.

Transmission plan for the Ilam area is shown in Figure 2.2.-3. The existing 33 kV line from Anarmani substation to Dhulabari branches at Charali, with one branch extending northward to Handiya khola, and is currently used at 11 kV. Under the 7th Power Project, this line will be extended through Kanyam and Phikkal Bazar, where one branch will continue north to Pasupati Nagar and another branch westward through Aitabare, Thulo

Godak, and Maibeni to Ilam N.P.. A 33 / 11 kV / 3 MVA substation will be constructed near from Ilam N.P., from which three 11 kV distribution lines will service Soktim to the south, Shakheijung to the northwest and Dharapani to the north. At present the power station at Ghorke delivers power via a 11 kV distribution line to Pasupati Nagar. However, with construction of the 33/11 kV substation at Ilam Bazar, both these areas will be simultaneously connected to the larger transmission network.

## 2.3 Demand Forecast and Development Plan

### 2.3.1 Past Power Demand

Peak generation (MW) and sold power nationwide for the period FY 1986 ~ FY 1993 are shown in the Table 2.3-1:

**Table 2.3-1 Peak Generation and Sold Power**

| | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|
| Peak generation (MW) | 110.000 | 126.000 | 141.000 | 150.000 | 176.000 | 204.000 | 216.000 | 214.040 |
| Available power supply (GWh) | 488.500 | 571.000 | 628.500 | 672.300 | 773.842 | 906.283 | 981.105 | 963.314 |
| Hydropower | 427.400 | 537.300 | 560.200 | 558.300 | 712.312 | 870.203 | 869.980 | 804.050 |
| Diesel | 3.300 | 1.100 | -- | -- | 0.858 | 0.800 | 31.540 | 47.290 |
| Purchased power | 57.800 | 32.600 | 68.300 | 114.000 | 60.672 | 35.280 | 79.585 | 111.974 |
| India | 57.800 | 32.600 | 68.300 | 114.000 | 60.672 | 33.700 | 54.938 | 82.223 |
| BPC | -- | -- | -- | -- | -- | 1.580 | 24.647 | 29.751 |
| Sold power (GWh) | 341.418 | 402.596 | 465.145 | 496.137 | 548.069 | 669.400 | 737.352 | 733.754 |
| Domestic | 140.596 | 162.329 | 185.746 | 193.308 | 231.396 | 261.399 | 275.248 | 268.987 |
| Non-commercial | 31.462 | 27.390 | 52.358 | 48.059 | 47.433 | 46.230 | 46.684 | 48.937 |
| Commercial | 19.336 | 21.963 | 25.401 | 30.778 | 33.712 | 36.640 | 45.200 | 49.125 |
| Industrial | 110.382 | 148.477 | 161.577 | 175.262 | 178.321 | 206.881 | 246.374 | 269.979 |
| Water supply | 11.268 | 15.312 | 7.016 | 7.344 | 11.928 | 15.831 | 14.936 | 14.530 |
| Irrigation | -- | -- | 9.358 | 15.626 | 11.965 | 11.851 | 12.769 | 11.627 |
| Street lighting | 3.667 | 3.858 | 6.163 | 5.091 | 7.295 | 7.308 | 7.802 | 8.180 |
| Temporary supply | 1.533 | 1.240 | 0.705 | 0.677 | 0.403 | 0.428 | 1.003 | 1.101 |
| Transport | 1.716 | 1.569 | 0.763 | 2.287 | 2.060 | 1.825 | 1.506 | 1.497 |
| Temple | -- | -- | 0.005 | 0.109 | 0.270 | 0.369 | 0.419 | 0.469 |
| Total (internal sales) | 319.960 | 382.138 | 449.092 | 478.541 | 524.782 | 588.760 | 651.941 | 674.434 |
| Bulk supply | 21.458 | 20.458 | 16.053 | 17.596 | 23.287 | 80.640 | 85.411 | 59.320 |

The average annual growth rates for peak generation and sold power for the period 1986 ~ 1993 are both around 11%.

Type of power consumption, numbers of consumers, annual consumed energy and peak generation for the period 1986 ~ 1993 are as shown in Table 2.3-2.

## Table 2.3-2 Numbers of Consumers by Sector

| | | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|---|---|
| Consumer Units by Sector | Domestic | 175,860 | 208,870 | 230,178 | 251,758 | 274,921 | 304,480 | 337,715 | 371,975 |
| | Non-commercial | 1,881 | 1,768 | 2,403 | 3,477 | 4,506 | 5,633 | 6,065 | 6,340 |
| | Commercial | 527 | 315 | 641 | 1,678 | 1,758 | 1,827 | 1,378 | 1,536 |
| | Industrial | 4,575 | 5,464 | 6,181 | 6,769 | 7,482 | 8,382 | 9,113 | 9,595 |
| | Water service | 277 | 351 | 77 | 105 | 112 | 119 | 124 | 131 |
| | Irrigation | -- | -- | 311 | 343 | 382 | 420 | 512 | 463 |
| | Street lighting | 318 | 675 | 1,474 | 385 | 517 | 532 | 547 | 367 |
| | Temporary | 113 | 275 | 145 | 104 | 123 | 136 | 191 | 183 |
| | Transportation | 8 | 8 | 8 | 9 | 9 | 9 | 8 | 8 |
| | Temples | -- | -- | 59 | 152 | 205 | 247 | 335 | 398 |
| | Total (in Nepal) | 183,559 | 217,726 | 241,477 | 264,780 | 290,015 | 321,785 | 355,988 | 390,996 |
| | Wholesale | 3 | 4 | 2 | 4 | 4 | 5 | 5 | 4 |
| | Grand total | 183,562 | 217,730 | 241,479 | 264,784 | 290,019 | 321,790 | 355,993 | 390,996 |
| Sold energy (GWh) | | 341.418 | 402.596 | 465.145 | 496.137 | 548.069 | 669.400 | 737.952 | 733.754 |
| Annual consumed energy per consumer unit (kWh) | | 1.86 | 1.85 | 1.89 | 1.87 | 1.89 | 2.08 | 2.07 | 1.88 |
| Peak generation (MW) | | 110.00 | 126.00 | 141.00 | 150.00 | 176.00 | 204.00 | 216.00 | 214.04 |
| Peak power per consumer unit (kw) | | 0.600 | 0.579 | 0.584 | 0.566 | 0.607 | 0.634 | 0.607 | 0.547 |
| % of consumption units out of total accounted for by domestic sector | | 95.8 | 95.6 | 95.3 | 95.1 | 94.8 | 94.6 | 94.8 | 95.1 |

As can be seen from the above table, the percentage of consumption units out of the total accounted for by the domestic sector far exceeds that for commercial and industrial sectors, maintaining a level around 95% for the 8 year period.

On the other hand, consumed energy per consumer unit and peak generation have shown almost no change during the same period, with levels at around 1.9 kWh and 600 W, respectively.

Thus, the greater portion of power consumption in Nepal is for domestic purposes, and it can be said that the rate at which the number of consumer units in this category increases governs generated energy and peak power demand.

**2.3.2 Monthwise Peak Load**

Month-wise energy consumption for 1989/1990 and month-wise peak load for 1990/1991 are shown in Figure 2.3-1.

As a general trend, consumption is greater in the winter months and less in the summer months. In view of the fact that most power consumption is for lighting, it can be interpreted that this is due to the fewer hours of daylight in the winter.

**2.3.3 Daily Load Curve**

Daily load curves for one week in December 1992 are indicated in the Figure 2.3-2

Daily load shows only very minor fluctuation with the exception of the afternoon hours of Saturday (weekly holiday in Nepal), where it is slightly less. The reason for this is attributable to the fact that power consumption is mainly for domestic lighting and hence exhibits virtually no change from day to day.

However, since peak power generation is 170 MW for the above example (with load shedding already being imposed), it is not representative of daily load characteristics for the same month in other years.

Average load factor for the example is 62%.

A daily load curve example for January 1991 (when load shedding was not being imposed) is shown in the Figure 2.3-3.

In Figure 2.2-2 peak load was restricted to approximately 1½ hours due to the imposed blackouts. In contrast, Figure 2.2-3 shows peak load for roughly a 3½ hour period (17:30~21:00). Load factor for the second example is 64%, which is a somewhat high value for a load attributable mainly to lighting.

**2.3.4 Demand Forecast**

On the basis of past sold power and power generation, the NEA forecast for annual generated power and peak generation as of August 1993 is indicated in Table 2.3-3 and Figure 2.3.4.

Mean growth rates for sold power and peak generation for the period 1974/1975 to 1990/1991 are 12.7% and 11.4%, respectively. The subject demand forecast estimates future increase rates for both of these at around 10%, which is considered reasonable.

Given the validity of such a forecast, 475 MW of peak capacity (twice the current peak generation) would be necessary by the year 2000. Accordingly, due to the fact that the power development planning described in the subsequent section is not on schedule, power shortages will be unavoidable over the immediate future

**Table 2.3-3 Demand Forecast**

| Year | Generated Power (GWH) | Annual Growth Rate (%) | Peak Generation (MW) | Annual Growth Rate (%) |
|---|---|---|---|---|
| 1993 | 998.5 | 1.8 | 228.0 | 2.6 |
| 1994 | 1,091.7 | 9.3 | 249.2 | 9.3 |
| 1995 | 1,218.9 | 11.7 | 276.1 | 10.8 |
| 1996 | 1,377.7 | 13.0 | 311.4 | 12.8 |
| 1997 | 1,547.6 | 12.3 | 349.0 | 12.1 |
| 1998 | 1,726.2 | 11.5 | 387.0 | 10.9 |
| 1999 | 1,927.9 | 11.7 | 430.0 | 11.1 |
| 2000 | 2,134.2 | 10.7 | 475.4 | 10.6 |
| 2001 | 2,350.6 | 10.1 | 520.9 | 9.6 |
| 2002 | 2,582.0 | 9.8 | 569.5 | 9.3 |
| 2003 | 2,831.1 | 9.6 | 621.1 | 9.1 |
| 2004 | 3,110.0 | 9.9 | 679.0 | 9.3 |
| 2005 | 3,418.8 | 9.9 | 742.8 | 9.4 |
| 2006 | 3,758.3 | 9.9 | 812.7 | 9.4 |
| 2007 | 4,136.2 | 10.1 | 890.5 | 9.6 |
| 2008 | 4,557.0 | 10.2 | 976.5 | 9.7 |
| 2009 | 5,024.7 | 10.3 | 1,071.3 | 9.7 |
| 2010 | 5,543.1 | 10.3 | 1,176.3 | 9.8 |
| 2011 | 6,114.7 | 10.3 | 1,292.3 | 9.9 |
| 2012 | 6,745.7 | 10.3 | 1,420.1 | 9.9 |
| Mean Annual Growth Rate | | 10.6 | | 10.1 |

## 2.3.5 Development Plan

Various development plans have been proposed to respond to the future power demand anticipated under the long term forecast. However, particularly in the case of large scale projects, finding sources of funding had been difficult up to this time, although now with the cooperation of various donor countries and agencies some of these large schemes have begun to move forward. Nevertheless, none of the projects indicated in Table 2.2-4 with the exception of the Khimti khola project under the BPC have gone to construction as of yet.

Of the plans by NEA to develop power sources, only those for isolated mini hydopower schemes have taken shape as of the present. Nevertheless, the large scale Arun III project is ready to go to construction next year. In light of the aforementioned failure of large scale power schemes to proceed on schedule, it is impossible at this point to expect immediate and sizable improvement in the power supply situation to the national grid. Against this background, however, improvement of existing power facilities and plans to expand transmission and distribution capacity are proceeding smoothly with assistance from various donor nations and agencies. Chief among these are:

- Kulekhani power station disaster prevention project
  Funded under yen loan with budget of ¥ 27.1 billion

- Trisuli power station improvement project

- Transmission and distribution expansion project for Katmandu valley. Funded under Japanese Grant Aid

- 7th Power Project
  Rural electrification and transmission, distribution and substation construction under ADB loan

- Power loss reduction project
  Power sector efficiency project under multilateral funding from IDA, OECF, Nordic Fund, etc.

The following projects to develop new power sources are awaiting arrangements for funding:

- Arun 3 hydropower development project (402 MW)
  The feasibility study for this project was completed in 1987 under JICA cooperation. Detailed design was subsequently performed by a team lead by a German consultant. However, the large scale nature of the project (402 MW) has made arrangements for funding difficult. The World Bank, ADB and German funding sources have reached an agreement to develop half of the generating capacity (201 MW), with each party contributing US$ 135 million, respectively; however, the Japanese government has not as yet made a final commitment.

- Kali Gandaki A power project (140 MW)
  The feasibility study for this project has been completed under UNDP cooperation. Detailed design is currently in progress by joint venture of MKE (USA), Norconsult (Norway) and IVO (Finland). Funding arrangements remain to be made in view of the scheme's relationship to the above Arun III project. However, NEA hopes to have the facility on line by 1999, and is in the process of negotiating with various potential funding sources in this regard.

- Sapta Gandaki power project (225 MW)
  The feasibility study for this project was completed in 1982 under JICA cooperation. However, due to the priority being given the Arun III and Kaligandaki A projects, no move has been made on this project to bring it to implementation.

- Jhimruk power project (12 MW)
  This project is currently under construction by the private firm BPC. It is scheduled to go on line in 1995.

- Khimti Khola power project (60 MW)
  This project is currently under planning by BPC. It is scheduled to go on line in 1998.

- Modi Khola power project (14 MW)
  The feasibility study for this project was completed in 1992 by NEA. Detailed design is currently in progress under a grant from South Korea. Although a funding source for construction remains to be arranged, NEA is hopeful that the facility can go on line by 1997~1998.

- Medium sized power projects
  NEA has begun studies on medium sized power schemes (20~60 MW), particularly at locations where new access road construction is not necessary, in view of the longer period of time required to secure funding for large scale projects such as Arun 3, Kali Gandaki and Sapta Gandaki as well as the difficulties in attempting to implement more than one such large scale project at a time. Among these are the Bhote Kosi and Middle Marshandi schemes etc.

With implementation of the Arun III project still pending, the current unstable power supply situation is anticipated to continue. As an immediate alleviating measure, however, a 42 km long 132 kV transmission line is currently under construction between Duhabi (Nepal) and Kataiya (India) for the import of 30 MW of power from neighboring India from a target date of June 1995.

### 2.3.6 Demand in the Ilam Area and Pasupatinagar

Power situation in the area centering on Ilam N.P.:

| | | |
|---|---|---|
| Power source: | diesel generator | |
| Rated capacity: | 264 kW | 350 kVA (400 V) |
| Actual performance: | 310 V | 310 A ($1.73 \times 0.31 \times 310 = 166$ kW) |
| | (according to operating staff report, around 180 kW) | |

| | | |
|---|---|---|
| Consumer units: | Total no. of consumers | 339 |
| | residences: | 260 |
| | non commercial: | 63 |
| | commercial: | 13 |
| | street lighting | 1 |
| | temporary | 2 |

under application for connection: 221 consumer units

Although the rated voltage for the generator is 400 V, it operates at 310 V due to over capacity of the present diesel engine. This voltage drop is considered attributable to overloading. Accordingly, load (including loss) is computed at:

$$166\text{kW} \times \left(\frac{400}{310}\right)^2 = 276\text{kW}$$

Power per consumer unit is computed at:

$$276 \text{ kW} / 339 = 0.815 \text{ kW}$$

This exceeds the past peak power per consumption unit of 0.6 kW in total for the national grid. Power generation is during the 4 hour period 18:00~22:00 in winter, and 18:30 ~ 22:30 in summer. Since the amount of energy generated (kWh) will change with the length of operation per day, peak capacity (kW) can be focused on as the principal concern in the case of an isolated power station such as the one at Ilam. If the consumer units under application are added to the total, the following peak capacity is necessary:

$$0.815 \text{ kW} \times (339 + 221) = 456 \text{ kW}$$

Government run tea estates in the Ilam N.P. use private 18 hp diesel generators for power. The reason for this is that (i) power is not needed all day long and (ii) voltage drop in the case of the Ilam diesel generator is so large that electrically operated equipment and machinery cannot function.

One photocopying establishment at Ilam Bazar as well operates for 2 hours in the morning and 2 hours in the afternoon utilizing a private generator.

Taking into consideration the above, it can be considered that sizable latent demand for power would emerge given power availability all day long and voltage close to the equipment's original rating in the case of the Ilam diesel generator.

The area centering around Pasupatinagar near the border with India is serviced by a 64 kW power station at Ghorke. The current number of consumers is reported to total 230 with another 200 under application. Since the Ghorke station is hydropower, it would be possible for all day power generation if a secure generating discharge is available. In the winter season, however, equipment is operated only during the main early morning, afternoon and evening hours relying on ponded water due to low discharge. At present, 1 generating unit of the 2 units is out of order. However, even with both units operable, voltage is less than 300 V despite an equipment rating of 400 V. Peak generation per consumer unit which can be expected from the system is 0.494 kW:

$$64\text{kW} \div 230 = 0.278 \text{ kW (: power demand / consumer unit)}$$

$$0.278 \text{ kW} \times \left(\frac{400\text{v}}{300\text{v}}\right)^2 = 0.494 \text{ kW}$$

Potential demand including the consumer units under application is estimated as:

$$0.494 \text{ kW} \times (230 + 200) = 212 \text{ kW}$$

At the cheese factory in Pasupatinagar, voltage drop is so great (reportedly dropping as low as 280 V) that a 4.5 kW diesel generator has been purchased in order to keep the factory producing. Should the power generating facilities be expanded in the future, peak generating capacity of 10 kW would be desirable. Given a reliable supply of good quality power, consumers wanting access to the same could be expected to increase.

### 2.3.7 Anticipated Developments given Stable and Adequate Power Supply

Ilam district is a major tea producing area in Nepal. Livestock industry is also widespread, with the area producing 20,000 *l* / day. Of this, 60% (12,000 *l*) is shipped out to other districts. The district is also favorable for agriculture given its abundant rainfall. In light of the above, the following can be expected for the area given stable and adequate power supply:

① Additional tea estate

It is hoped that new tea estates will be established in addition to the 4 at Ilam, Kanyan, Soktim, and Chilinkot.

② Milk chilling plant

Refrigeration facilities are necessary to improve the efficiency of shipping of milk.

③ Cardamom spice drying

Drying of cardamom spice produced in the area by electrically operated equipment would improve efficiency and quality.

④ Paper manufacture

Construction of paper (bamboo, etc. as raw material) manufacturing plant would be possible.

⑤ Pump lift irrigation

At present, all irrigation in the area is by gravity flow. Pump lift irrigation would permit expansion of cultivated area.

⑥ Social infrastructure

Demand exists at hospitals, schools etc. for power to operate not only lighting, but equipment and machinery as well.

### 2.3.8 Power Demand under the 7th Power Project

The 7th Power Project is currently under construction and includes a 33 kV transmission line to Ilam, a substation at Ilam Bazar and 11 kV distribution line in the Ilam district.

As the transmission line from the existing line to Ilam Bazar is routed through Jhapa district, demand forecast in the 5th year and 10th year (after completion of construction ) includes the demand for 4 power consumption areas (Barne tea estate, etc.) in the Jhapa district along the transmission line. Table 2.3-4 indicates forecast for Ilam district only.

| | 5 th year | 10th year |
|---|---|---|
| Power demand | 5,012 GWh | 8,300 GWh |
| Peak power | 2,840 kW | 4,182 kW |

According to Table 2.3-4, peak demands in the 5th year for Ilam N.P. and Pasupatinagar are 394.7 kW and 126.1 kW, respectively. However, these values are lower than anticipated potential demand for Ilam and Pasupatinagar (465 kW and 212 kW, respectively) estimated in section 2.3.6.

Under the 7th Power Project, Kolbung village along the transmission line and Ghorke village (which has an existing hydropower generating system) are excluded from the electrification target area. However, because both locations can be readily connected to the said system, these are included in the demand forecast indicated in Table 2.3-4, in which peak power demand for Ilam district is anticipated at 3,163 kW and 4,636 kW for 5 years in the future and 10 years in the future, respectively.

### 2.3.9 Power Demand under the GTZ Small Hydropower Master Plan

The extent of electrification targeted for Ilam district under this plan is essentially the same as that under the 7th Power Project. However, whereas the plan includes Gorke, Mangalbare, Sangrumba and Soyang V.D.C. (village development committee), Sekhejung and Soyak V.D.C. are excluded. Demand forecast for 2015 is roughly the same as that under the 7th Power Project for 10 years in the future, estimating total peak generation at 5,200 kW. Table 2.3-4 compares the peak generation envisioned under the master plan. Figure 2.3-6 shows a comparison of the range of electrification under the said master plan and the range envisioned under the 7th Power Project.

### 2.3.10 The Status of Ilam Small Hydropower Development within the Context of the Above Described Projects and Planning

Approximately 6,200 kW of generating capacity are to be created under the Ilam Small Hydropower Development Project. Under the original plan, an independent power system was to be established for the Ilam area; however, this concept was reassessed in light of the fact that the 7th Power Plan, now under construction, is targeted for completion by 1996. Given that detailed design and construction for the Ilam Small Hydropower Development Project is anticipated to require 3 years, the facilities under the 7th Power Project will be in place when the Project is completed. Accordingly, the Ilam small hydropower scheme can be formulated on the premise that it will be connected to the national grid.

As a result, power demand is not anticipated to pose a problem since energy produced at the Ilam small hydropower station can be effectively utilized within the national grid in the Eastern Development region, centering on Ilam district.

## Table 2.3-4 Demand Forecast in Ilam Area

| National population census (1991) | | | 7th Power Project | | | | | | | Small Hydropower Master Plan |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | S.No. | Village Name | No. of houses | 5th year | | 10th year | | Demand in 2015 (kw) |
| Village/town | Population | No. of Houses | | | | Energy (GwH) | Demand (kw) | Energy (GwH) | Demand (kw) | |
| Kolbung | (3623) | (666) | — | — | (340) | (283.8) | (166.4) | (458) | (234.1) | — |
| | | | 17.0 | Harkate | 75.0 | 40.4 | 22.1 | 72.2 | 35.8 | |
| | | | 18.0 | Ambi | 120.0 | 75.1 | 38.1 | 136.5 | 61.9 | |
| | | | 21.0 | kanyam | 200.0 | 248.5 | 164.3 | 353.9 | 204.5 | |
| | | | 23.0 | Sidhigaon | 185.0 | 120.1 | 59.7 | 218.9 | 97.1 | |
| Kanyam | 5,950.0 | 1,041.0 | | | Total 580.0 | 484.1 | 284.2 | 781.5 | 399.3 | 408.0 |
| | | | 22.0 | Paltaga | 30.0 | 16.2 | 8.9 | 29.0 | 14.4 | |
| | | | 24.0 | Mamegaon | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| | | | 25.0 | Fikkal Bazar | 400.0 | 256.9 | 128.5 | 467.8 | 209.1 | |
| | | | 26.0 | Barbote | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| | | | 31.0 | Dhore | 100.0 | 64.2 | 32.1 | 116.9 | 52.3 | |
| | | | 32.0 | Pandam | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| Fikkal Bazar | 7,746.0 | 1,462.0 | | | Total 980.0 | 611.2 | 310.5 | 1,109.9 | 504.7 | 463.0 |
| | | | 30.0 | Tinkhutte | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| | | | 80.0 | Katebong | 100.0 | 64.2 | 32.1 | 116.9 | 52.3 | |
| | | | 29.0 | Baudhadham | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| Pasupatinagar | 6,697.0 | 1,197.0 | | | Total 400.0 | 246.8 | 126.1 | 447.7 | 204.9 | 458.0 |
| | | | 38a | Keraban | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| | | | 38b | Maghe | 120.0 | 75.1 | 38.1 | 136.3 | 61.9 | |
| | | | 38c | Suntale | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| | | | 40.0 | Aitabare | 70.0 | 37.9 | 20.8 | 67.8 | 33.6 | |
| | | | 41.0 | Tinghare | 27.0 | 14.3 | 7.8 | 25.5 | 12.7 | |
| Panchakanya | 6,676.0 | 1,201.0 | | | Total 317.0 | 181.5 | 96.3 | 326.4 | 156.2 | 337.0 |
| | | | 42.0 | Jaubari | 100.0 | 64.2 | 32.1 | 116.9 | 52.3 | |
| | | | 39.0 | Jarsinggaun | 120.0 | 75.1 | 38.1 | 136.3 | 61.9 | |
| | | | 44.0 | Thulogodak | 100.0 | 64.2 | 32.1 | 116.9 | 52.3 | |
| Godak | 3,410.0 | 632.0 | | | Total 320.0 | 203.5 | 102.3 | 370.1 | 166.5 | 181.0 |
| | | | 48.0 | Dangsarang | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| | | | 49.0 | Bhuteni | 40.0 | 21.7 | 11.9 | 38.7 | 19.2 | |
| | | | 60.0 | Namsaling | 300.0 | 192.7 | 96.4 | 350.8 | 156.8 | |
| Namsaling | 5,107.0 | 896.0 | | | Total 390.0 | 241.5 | 123.1 | 437.9 | 200.0 | 281.0 |
| | | | 54.0 | Tea Estate | 150.0 | 691.3 | 547.0 | 765.4 | 576.3 | |
| | | | 54a | Soktim | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| | | | 55.0 | Chisapani | 100.0 | 64.2 | 32.1 | 116.9 | 52.3 | |
| | | | 57.0 | Mailbase | 30.0 | 16.2 | 8.9 | 29.0 | 14.4 | |
| | | | 56.0 | Pangapari | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| Chisapani | 3,456.0 | 646.0 | | | Total 380.0 | 825.9 | 617.6 | 1,008.1 | 691.0 | 525.0 |
| | | | 51.0 | Soyak | 300.0 | 192.7 | 96.4 | 350.8 | 156.8 | |
| | | | 52.0 | Simle | 60.0 | 32.5 | 17.8 | 58.1 | 28.8 | |
| Soyak | 2,755.0 | 494.0 | | | Total 360.0 | 225.2 | 114.2 | 408.9 | 185.6 | — |
| Sakhejung | 3,113.0 | 545.0 | 75.0 | Sakhejung | 450.0 | 284.0 | 143.4 | 516.2 | 233.1 | — |
| | | | 74.0 | Waphrung | 250.0 | 155.5 | 79.1 | 282.3 | 128.5 | |
| | | | 73.0 | Phudok | 250.0 | 155.5 | 79.1 | 282.3 | 128.5 | |
| Shantidanda | 4,366.0 | 781.0 | | | Total 500.0 | 311.0 | 158.2 | 564.6 | 257.0 | 216.0 |
| | | | 72.0 | Mailbase | 130.0 | 80.5 | 41.0 | 146.0 | 66.7 | |
| | | | 69.0 | Dharapani | 80.0 | 43.3 | 23.7 | 77.4 | 38.4 | |
| | | | 68.0 | Mandreni | 90.0 | 48.7 | 26.7 | 87.1 | 43.2 | |
| | | | 67.0 | Biblyate | 75.0 | 40.4 | 22.1 | 72.2 | 35.8 | |
| | | | 66.0 | Chureghati | 25.0 | 13.3 | 7.3 | 23.8 | 11.8 | |
| | | | 65.0 | Ghosgaon | 30.0 | 16.2 | 18.9 | 29.5 | 14.4 | |
| Barbote | 4,713.0 | 862.0 | | | Total 430.0 | 242.4 | 139.7 | 436.0 | 210.3 | 233.0 |
| | | | 50.0 | Keureni | 60.0 | 32.5 | 17.8 | 58.1 | 28.8 | |
| | | | 46.0 | Golakhark | 300.0 | 192.7 | 96.4 | 350.8 | 156.3 | |
| | | | 58.0 | Balangaon | 200.0 | 128.5 | 64.3 | 233.9 | 104.5 | |
| | | | 61.0 | Dhobidhara | 150.0 | 91.3 | 47.0 | 165.4 | 76.3 | |
| | | | 59.0 | Mahabhir | 50.0 | 27.1 | 14.8 | 48.4 | 24.0 | |
| | | | 78.0 | Ilam Bazar | 550.0 | 683.0 | 394.7 | 1,036.9 | 583.0 | |
| Ilam N.P. | 13,150.0 | 2,427.0 | | | Total 310.0 | 1,155.1 | 635.0 | 1,893.5 | 972.9 | 935.0 |
| Gorkhe | (3410) | (632) | — | — | (320) | (267.1) | (156.8) | (431.1) | (220.3) | 369.0 |
| Under 7th Power project | | 1,218.4 | | | 6,417 | 5,012 | 2,840 | 8,300 | 4,182 | |
| 7th power project + Gorkhe + Kolbung | | (13,482) | | | | | (3163) | | (4636) | — |
| Soyang | 4,342.0 | 741.0 | | | | | | | | 229.0 |
| Mangalbare | 5,539.0 | 963.0 | | | | | | | | 317.0 |
| Sangrumba | 4,599.0 | 827.0 | | | | | | | | 262.0 |
| Small Hydropower Master Plan | | 14,308 | | | | | | | | 5,200 |

## 2.4 Necessity for the Ilam Small Hydropower Development Project

### 2.4.1 Need for Medium to Small Scale Hydropower

The present power shortage problem in Nepal is not the result of dwindling hydropower potential, this still remains vast, but rather an exaggerated focus on large scale hydropower development schemes.

With the exception of isolated systems of mini hydro for electrification of remote area, almost all hydropower schemes being pursued to date are medium to large scale. The Arun 3 and Kali Gandaki projects, planning for which is at the most advanced stage among the various hydropower projects under consideration, have respective capacities of 201 MW and 140 MW, which are both extremely large considering the fact that present peak power load in Nepal is 210 MW. Due to the scale of such projects, they are formulated on the premise that multilateral funding will be used for their implementation. Thus, only one project at a time can be effectively pursued, and regardless of which project is selected for implementation, the others will accordingly suffer delay in execution. It is difficult to determine priority ranking in this regard as well as to bring multilateral parties into agreement with regards to conditions for financing. The above factors combine to place severe constraints on, and subsequent delay in, the realization of large scale hydropower projects.

In order to address this power development situation, the Nepalese government has undertaken to:

① Develop hydropower with financing from the private sector

② Develop medium to small scale hydropower schemes, which can be completed over the short term

Under ① above, the private firm BPC is currently constructing the Jimruk power scheme (12 MW). BPC is further jointly pursuing the Khimti khola scheme (60 MW) with Himal Power Corporation. Power Development Nepal is showing interest in the construction of the Modi khola scheme (14 MW) now under detailed design with assistance from South Korea. In addition, the Swetbarab Power Supply Company is expressing interest as well in the Liping khola (1,600 kW), Langtang khola (5 MW) and Bhote kosi (35 MW) schemes.

In the case of small to medium scale projects, funding from a single donor nation or from the private sector becomes feasible. In some cases it is possible to even carry out such projects under grant aid such as in the case of the Andi khola (5 MW) scheme. In comparison to large scale development, these smaller schemes feature relatively short construction period, and prompter results.

Furthermore, the nature of the overall power structure in Nepal creates a need for the entire range of large, medium and small scale power stations, each with their specific roles within the system.

### 2.4.2 Regional Balance

The Eighth National Plan of HMGN clearly sets reduction of regional imbalances as one of the three broad policies under national development. Distribution of existing generating facilities shows that even within the Eastern Division, power stations are concentrated in the eastern part of the division in Mechi and the Kosi Zone, where they are connected to the national grid, and comprise the Morang multi fuel (26 MW), Dharan (0.62 MW), Biratnagar (2.53 MW) and the Bhadrapur (1.38 MW) schemes, all of which are diesel plants. However, only the Morang scheme is operational, and even in the case of this plant, 2 of the 4 generating units are under repair. The bulk of the hydropower generating plants which form the mainstay of Nepal's generating capacity are concentrated in the Central and Western divisions. Even with electrification of the Ilam area, it is at the terminus of the power network and thus would still constitute an area most susceptible to the effects of power shortage. Given the fact that to alleviate the current power shortage situation, 6 MW of power is being imported from Kataiya substation in India for emergency supply independent of the national grid to Dharan and Dhankuta in the Kosi Zone, it is necessary to distribute power sources in a balanced manner by region. In this light, the Ilam Small Hydropower Development Project to establish a power source at the extreme eastern part of the Eastern Zone is highly significant from the standpoint of stable power supply.

### 2.4.3 Features of the Ilam Area

It is extremely difficult to objectively rank areas in terms of priority for electrification. Nevertheless, Ilam is a major production area for tea and spice (cardamom), as well as a major area of dairy farming activity. Commercial exchange with India via Pasupatinagar is active as well. Although Pasupatinagar is not a district capital it is nevertheless a very important settlement in the area and is specially fed with power from the Gorke hydropower station

From the following standpoints, it is clear that Ilam is an important area to be developed for Nepal as a whole.

## 2.5 Relationship with other Existing and Future Water Use Facilities

### 2.5.1 General

There are existing diversion structures for irrigation both upstream and downstream of the proposed intake site for the Project. Respective maximum diversion discharges at these structures are 0.3 and 0.2 $m^3/s$. There is also an existing plan to divert 1.1 $m^3/s$ of discharge from a point 19 km upstream of the Project intake site, and to convey this discharge by tunnel through the ridge in western Ilam for irrigation in the southern part of Ilam Bazar.

It can be assumed that diversion at the 2 existing irrigation structures is primarily in mid May ~ mid July for rice plantation. Accordingly, it can be concluded that diversion is thus during a period of abundant discharge with no impact on hydropower development planning.

Intake structure and canal under the Project are to be planned at sufficient capacity to accommodate future irrigation discharge as well. An overflow type diversion structure can be included at the regulating pond envisioned for the southern part of Ilam Bazar to divert discharge for irrigation. However, consultations between authorities respectively responsible for power generation and irrigation will be necessary prior to implementation of such planning.

Even if the tunnel portion which accounts for the major part of the headrace canal length is excavated at the minimum required cross section, this will be sufficient to accommodate both the envisioned power generating and irrigation discharges. On their points, irrigation planning will have no cost escalation impact on the Project.

### 2-5-2 Results of investigation on existing irrigation water supply facilities and plans

The attached Table 2.5-1 was prepared on the basis of the public works programs made by the chief of Ilam District Irrigation Office under the Ministry of Water Resources concerning the present status of Puwa Khola water use programs for irrigation sector of Ilam District as of 1993.
From the Table, the most relative programs to this Project among them one;

(1) No.4, Puwa Khola (middle) Irrigation Plan :
Which is located about 19 km upstream side of the Project intake dam site having the design discharge of 1.1 $m^3$/sec.

(3) No.5, Lamaduwari Irrigation Supply Water Project :
Which is located about 5 km downstream side of the Project intake dam site having intake discharge of about 0.2 $m^3$/sec and is now under operation.

In addition to the above public section, there is one private sector project of irrigation water supply which intakes water from Ghatte Khola, a tributary of Puwa Khola, about 0.2 km upstream side of the Project intake dam site having intake discharge of about 0.3 $m^3$/sec. and is now under operation.