第Ⅵ章　本格調査概要

VI－1　調査内容

本調査は1992年12月22日ＪＩＣＡ・ＮＥＡ間で合意締結されたＳ／Ｗに基き実施されるＦ／Ｓ調査であり

(1) Identification Stage

(2) Field Investigation Stage

(3) Feasibility Design Stage

の３段階に分けて実施される。

調査の詳細は下記の通りである。

・Identification Stage

(1) データ収集

a）気象データ及び情報

b）水文データ及び情報

c）地形図

d）地質データ及び情報

e）電力需給に関するデータ及び情報

f）地方社会経済データ及び情報

(2) 電力事情調査

a）既設の発電及び送電設備及びその運転状況の調査

b）電力需要の増加率、特性の調査検討

c）1982年から2005年までの電力需要及びピーク需要の調査及び予測

d）既存の電化計画の調査及び解析

(3) 現地踏査

a）プロジェクトサイトの地形及び地質に関する地表踏査（アクセス道路を含む。）

b）水文予備調査

c）社会的及び自然環境に関する予備調査

(4) サイト選定調査

a）プワ・コーラ川流域の総合開発を考慮した各種計画案の策定

b）技術的，経済的及び環境条件を考慮したサイトの選定

c）基本計画の作成

d）電化予定地域の選定

(5) 現地調査（測量，地質）の作業工程の作成

・*Field Investigation Stage*

(1) 地形測量

a）取水地点，導水路，ヘッドタンク，水圧管路，発電所地点の地形測量及び地形図の作成

(2) 地質調査

a）主要構造物の建設予定地点でのボーリング調査及び透水試験

b）主要構造物の建設予定地点での弾性波探査

c）立坑，横坑の試掘（必要に応じて）

d）現地あるいは実験室でのテスト

e）全体地質平面図及び導水路、水圧管路の地質縦断図の作成

(3) 水文調査

a）降雨量，河川流量及び流砂量の調査観測

b）河川流出に関する水文及び気象解析並びに堆砂量の推定

(4) 地方電化の現況調査

(5) 環境影響調査

・Feasibility Design Stage

(1) 小水力発電所，送電線，変電所の各種開発計画案の作成

(2) 開発計画案の比較検討及び最適計画の選定

(3) 予備設計

(4) 事業費積算

(5) 実施工程の作成

(6) 経済分析

(7) 財務分析

(8) 環境影響評価

VI－2　本格調査時に留意すべき事項

本格調査時に留意すべき点は下記の通りである。

VI－2－1　一般事項

イラム・バザールでのＮＥＡ供給の電力は、質（電圧，周波数）量（供給時間）共不十分である。したがって、照明，コピーマシン用等に携帯電源を準備する必要がある。

イラム・バザールには、ホテルと称する木賃宿があるが、浴室、シャワー設備等はなく、マット・シーツ・毛布等は、調査団側で準備するのが望ましい。ＴＶは電源があれば、インド放送が受信出来る。放送の約１／２は英語である。香港等衛星放送が受信可能であるが、アンテナの設置には関係当局の許可が必要である。

公衆電話は使用可能である。ミネラルウォーター，ビール，焼酎，米，鶏肉等はイラム・バザールで調達可能である。その他野菜を始め、副食物は品数が少なく、品物によりチャラリまで行く必要がある。

雨期は山ヒル、南京虫、毒蛇への対策が必要である。

VI－2－2　土木関係

(1)　発電計画

①　土木施設は、河川勾配が急であることより、堆砂，排砂に配慮した取水施設とする必要がある。

②　上流における灌漑計画

上流域には水資源省(Ministry of Water Resources）が計画中の灌漑計画がある。

しかし、水資源省の高官（次官）によれば本灌漑計画が実施される可能性は低く、イラム小水力発電プロジェクトのＦ／Ｓでは本計画を考慮する必要はないとのことである。しかし、灌漑計画について再度調査をして確認する必要がある。

③　発電方式として、流れ込み式及びダム貯水池式を比較検討の対象とする。

(2)　地形測量及び地質調査

本格調査の第２段階（Field Investigation Stage)で実施する地形測量、地質調査は現地業者に再委託する。調査団はそのため、第１段階（Identification Stage）

で現地業者の作業能力を把握した上で、作業工程計画及び仕様書を作成する。第２段階では現地業者の指導・監督及び調査結果の分析を行う。

(3) 水文資料

水資源省が管理する雨量観測所、流量観測所は、プロジェクト近傍に数地点ある。同省より資料は入手可能である。

しかし、それだけではダム取水地点の流量資料が不足と思われるので、他の観測地点との流量相関、雨量相関より類推する必要がある。

さらに、流量観測標を取水地点に新設して観測する必要がある。

(4) 地形図関係資料

ネパール地図局(Topography Department) が発行している地図で現在入手可能な最大縮尺は１／50,000で、プロジェクト流域は図番は72 $\frac{N}{13}$, 72 $\frac{N}{16}$ である。

Ｆ／Ｓ調査では、１／5,000 程度の図面が必要であるから、現在入手できる既存の航空写真より地形図を作成する。

構造物計画地点の実測地形図の縮尺は１／500～１／1,000程度とする。

ダム地点と発電所地点の標高差は計画上重要な要素なので水準測量により確認する必要がある。

(5) 地質関係資料

鉱山地質局(Department of Mines and Geology) が発行している東部ネパールの地質図１／250,000 があり、それによれば計画地点の南約10kmに東西に走る大規模な断層があるので、特にトンネル部岩盤の性状分布について十分注意して調査する必要がある。

地質は先カンブリア紀の結晶片岩が主体で片理面が発達していると思われるので掘削に伴う地辷りの可能性について調査する必要がある。

(6) 環境影響調査

環境は環境省(Ministry of Forest and Environment)の所管であるが、詳細調査項目は、ＮＥＡと協議して決める必要がある。調査はネパール側の専門家の参加を得て調査団が行う。

VI－2－3　電気関係

① ＮＥＡの 132kV基幹送電網（ＮＧＤ）に連系しており、イラム・バザールに最も近い変電所はアナルマニ変電所で、その設備容量は7.5MVA×２＝15MVA で運転開始は1990年である。

ＮＥＡの第７次電力プロジェクト計画によれば、イラム・バザールとアナルマニ変電所は1995年迄に33kV送電線で結ばれる事になっている。

しかし、前述33kV送電線のルートにはイラム小水力発電所計画が全然考慮されていない。従ってＦ／Ｓ調査に際して、33kV送電線プロジェクトの進捗状況（特にファイナンス面）をチェックし、ＮＥＡ及び関係コンサルタントと十分打合せを行う必要がある。特に新設発電所とイラム・バザール間の連系システムを明確にする必要がある。

② イラム発電所が33kV又は66kV,132kV等の送電線を介してＮＧＤに連系した場合、当発電所は送電線の末端に位置するので、発電所の電圧調整能力、送電線充電容量等について、系統計算をシュミレートしつつ、検討する必要がある。

③ 1992年12月17日（木）のイラム・ディーゼル発電所の最大負荷は、 145kWを記録し、同時刻の配電電圧は発電所出口で 170Ｖであった。定格電圧は 380Ｖ、配電方式は３相４線式である。また、需要家数は 330戸、配電損失はノンテクニカル・ロス（盗電等）を含め通常30％との事である。

前述の如き、低電圧配電しか出来ないので、需要は白熱電灯負荷に限定され、テレビ、冷蔵庫、蛍光灯等の負荷は皆無である。

従って、現時点で定格電圧の配電が実現した場合、現在の負荷(145kW×0.７＝100kW)は計算上 500kW前後に達する。つまり１需要家あたりの消費は 500kW／330＝1.６kWとネパールでは想像出来ない数値を示す。

この事は、発電所の計器エラー、計測ミス等によるものと考えられる。簡易測定器（電流計、電圧計）を持参し、再計測し、負荷の現状を確認する必要がある。

なお、イラム・バザールより約20km離れた地点にあるゴルケ(Gorkhe)部落には、64kWの水力発電所があり、同地区に給電しているので、その需給状況も調査する必要がある。

④ イラム地区は農村地区でイラム・バザールの人口約13,000人の相当部分は山地に点在している農家に分布しているものと思われる。

イラム・バザールの中心集落は人口密度も高く（家屋が密集している）既設配電網もあるので、需要想定も比較的容易と想像されるが、山腹に点在する農家の需要については、投資コスト，需要家の支払能力、盗電の防止等々を考慮して想定する必要がある。

第Ⅶ章　質問表及び収集資料リスト

Ⅶ－1　質　問　表

調査団がＮＥＡに提示した質問表及びＮＥＡの回答は添付のとおりである。

QUESTIONNAIRE

ON

ILAM SMALL HYDROPOWER DEVELOPMENT PROJECT

IN

THE KINGDOM OF NEPAL

December, 1992

PREPARATORY STUDY TEAM OF JICA

Legend
A:Collected by the Preparatory Study Team
B:To be Collected by the Feasibility Study Team

1. General

Item	Description	Availability	Remark
1. The Authorities directly and indirectly concerned with the implementation of the F/S of the ILAM Project	- Name of Authority & their Branch (NEA)	Nepal Electricity Authority (NEA)	
	- Address, Tel. & Telex in KATHMANDU (KTM) & near ILAM site	Durbar Marg, Kathmandu, Nepal Tel:226370, Tlx:2633NEAHO NP	
	- Annual report	A Year in Review FY1991/92	A
	- Responsible person	Mr. R. B. SHRESTHA	
	- Organization & directory of NEA		B
	- Available counterpart list (HMG/N) for the F/S of ILAM Project		

Speciality	Number	Speciality	Number
Civil Engineer	58	Sociologist	1
		Data Analyst	1
Electric Eng.	4	Biologist	1
Hydrologist	1	Surveyor	11
Geologist	13	Mechanical Eng.	6
Economist	1		
Clerk		Total	97
Typist			

2. Currency	- Exchange rate (US$, local currency)	As per the Rising Nepal Dated 15th Dec. 1992 1US$=48.33Rs.	
	- Name & location of bank (Exchangeable) in in KTM and near site		B

Item	Description	Availability	Remark
3. Published statistics	- Economy, industry, trade, population, agriculture production, etc.	Available in Statistical Department	B
4. Natural conditions in the working area (ILAM)	- Topography; Average land slope, altitude (maximum, minimum)		A
	- Climatic conditions; • Average Max. Temp. • Average Temp. • Average Min. Temp. • Max. Rainfall mm/D • Ave. Rainfall mm/M • Sunrise Time • Sunset Time • Number of Annual Fine Day • No. of Annual Rainy Day	}	B
	- Information for monsoon	June—September	
	- Annual Rainfall _____ (mm)	1500 - 1600mm	
	- Harmful animals, plants & water	}	B
	- Suitable watar for drinking • Bottled water • City running water • Stream water		
5. Access to the working area	- Route, transportation system etc.	•KTM to Ilam by Road: Trucks, Buses &Small Vehicles. •KTM to Biratnagar by Airplane, Biratnagar to Ilam by Road: Trucks, Buses, &Small Vehicles.	

Item	Description	Availability	Remark
6. Transportation of equipment and materials	- Route from KTM to the ILAM area - Means of transportation, cost (US$) - Time required	·KTM-Hetauda-Itahari-Birtamod -Charali-Ilam ·Calcutta port to Ilam-835Km Biratnagar to Ilam (a)134Km Asphalt (b) 47Km Gravel ·about 20hours from KTM to Ilam by Bus	
7. Customs clearance	- The authority concerned - Address, tel. & telex - How to obtain import and re-export license - Time required for customs clearance		B
8. National park	- Name of National park related to ILAM project - Information for the above park - Limit bounds		B
9. Environment	- Regulation, Law - Guideline of NEA	Ministry of Forest & Environment	B

2. Electric Power Situation in NEPAL

Item	Description	Availability	Remark
1. Existing supply facilities	- Power plants, substation (installed capacities) and transmission lines	Existing & Planned Power Plants 1992	A
	- Schematic and single line diagrams of national grid	Single Line Diagram NEA System	
2. Demand and supply records	- Record of peak kW, kWh from 1981 to 1990 including load curve (annual, monthly, daily) in whole NEPAL and ILAM area	Record of Reak Load-of Nepal System	A
3. Power consumption	- Power demand (kW), annual power consumption (kWh) in whole NEPAL and ILAM area from 1981 to 1990 a. Household b. Industries c. Agriculture d. Commercial e. Others	— ditto —	A
4. Demand forecast	- Long-term demand (max. kW, kWh) forecast in whole NEPAL and ILAM area	Demand Forecast for Energy and Power Consumption	A
5. Expansion program	- Expansion program of power system (power plant, substation, transmission line)	A Year in Review	A
	- Expansion program of distribution system in ILAM area	Electrification Scheme in 7th Power Projects	
6. Communication system	- Micro-wave, power line carrier (PLC), etc.	Micro-wave is available at Ilam	

Item	Description	Availability	Remark
7. Power flow and impedance map			B
8. Fault records	- Power facilities. By causes and units		B

3. Existing Survey Data

Item	Description	Availability	Remark
3-1 Topographical Maps			
(1) Existing maps	- Scale, mapping organizaiton, mapping data	1:50,000 & 1:250,000 maps are available at Topography Department	A
	- Index sheet		B
(2) Detailed topographical map at the vicinity of ILAM	- Scope, aerial surveying map or ground survying map, scale, mapping organization, mapping date, index sheet, spacing of contour lines		B
(3) Positive films	- Existence of duplicate map		B
	- If the said map exists, possibility of taking it outside the country		
(4) Control point	- Location and altitude of the control point at the vicinity of ILAM		B
(5) How to obtain the existing data and to take them outside the country	- How to obtain the required authorization		B
3-2 Hydrological and Meteorological Data			
(1) Rainfall	- Name and location map of the pluviometric stations	Available at Department of Hydrology & Meteorological Department	B
	- Daily rainfall record		

Item	Description	Availability	Remark
(2) Run-off	- Name and location maps of the water gauging stations - Daily run-off record		B
(3) Flood flow	- Record maximum flood		B
(4) Evaporation	- Evaporation and dispersion record - Observation location and observation method		B
(5) Climate	- Observation record of temperature, humidity, wind direction and wind velocity	Available at temperature, humidity	A
(6) Sedimentation	- Suspended sediment observation record - Silt sedimentation measurement record of existing storage reservoirs		B
3-3 Geological Data			
(1) Wide scope geological map	- Scale 1/125,000	Available at Topography Department	A
(2) Geological map at the vicinity of ILAM	- Scale 1/20,000	Not available	
(3) Geological survey reports	- Date of preparation, author(s)		B

Item	Description	Availability	Remark
(4) Reports on earthquake and volcanic activities	- Date of preparation, author(s)	Available at Department of Mines & Geology.	B
(5) Hydrological and geological data	- Ground water level observation - Spring water sites - Water quality sites - Suspended sediment observation		B

4. Matters Related to the Implementation of the Surveys

Item	Description	Availability	Remark
4-1 Preparation of the Topographical Map	- Policy and idea of the HMG/N authorities concerned, regarding the future preparation of this topographical map	No Restriction	
	- Name, address, equipment/facilities of the company able to carry out the mapping	Available at Topography Department	B
4-2 Implementation of the Seismic Prospecting	- Policy and idea of the HMG/N authorities concerned, regarding the implementation of seismic prospecting		B
	- Name, address, equipment/facilities of the company able to implement the seismic prospecting		
4-3 Implementation of Drilling Work	- Policy and idea of the HMG/N authorities concerned, regarding the implementation of the boring work		B
	- Name, address, equipment/facilities of the company able to implement the boring work		
4-4 Tests and Analyses	- Aggregates test, soil test, suspended sediment analysis, etc.		B
	- Name, address, equipment/facilities, etc., of the institution able to implement the tests and analyses		

5. Data for Preparation of the Development Plan

Item	Description	Availability	Remark
1. Report of existing plans proposed for development of the ILAM district.	- Prepared by: - Date of preparation - Evaluation of the report		B
2. Report of the existing plans proposed for development of ILAM Hydro.	- Prepared by: - Date of preparation - Evaluation of the report		B
3. Future development of the periphery of the Puwa River	- Flood control plan - Irrigation plan - Industrial estate plan		B
4. Access road			B
4-1 Existing Development Plan & Data approach to ILAM Site	- Name of authority - Plan information		

6. Construction Cost Estimation Data

Item	Description	Availability	Remark
1. Price list of materials, machinery and equipment	- Cement, aggregate, reinforcing bar, steel materials, mould made of steel, sheet piles, wood, dynamite, etc. (US$/ton)	available	A
2. Unit cost of labor	- Senior foreman, foreman, labor, miner, carpenter, bar bender, operator, driver, driller, grout man, etc. (US$/man-month)	available	A
3. Construction machinery	- Types and acquisition costs of domestic construction machinery Bulldozer, wheel loader, dump truck, truck mixer, compressor, concrete pump, vibrator, jack hammer, etc. (US$/unit)		B
4. Steel product import price (CIF)	- Gates, iron pipes, etc. (US$/ton) (Example of hydroelectric power plants under construction)		B
5. Electric machinery import costs (CIF)	- Turbine, generator, transformer, switch-board, etc. (Example of hydroelectric power station under construction)		B
6. Transmission line construc-tion cost	- US$/km	available	A
7. Custom duties for import	- Construction machinery and materials		B

Item	Description	Availability	Remark
8. Indemnification for resettlement of local residents	- Unit cost of indemnification of land, house, etc.		B
9. Interest rate			B
10. Escalation rate of commodity prices			B

7. Economic Evaluation

Item	Description	Availability	Remark
1. Unit cost of construction	- Unit cost for construction of thermoelectric and hydroelectric power plants under construction and completed of late (US$/kW, US$/kWh)		B
2. Economic evaluation	- I.R.R. of hydroelectric power plants completed of late or under construction		B
3. Tariff	- Tariff system	Electricity Tariff Rates November 1991	A
	- Averaged unit price (US$/kWh)		B
4. Fuel cost	- Fuel cost for thermal power plant		B
5. Operation, maintenance and management costs	- Costs of hydro and thermal power plants (US$/year)		B

8. Matters during the Field Survey Period

Item	Description	Availability	Remark
1. Necessity of field camp			B
2. Location of places appropriate as working bases			B
3. Hotel appropriate as working base or office	- Name, address, and charge of the hotel		B
4. Power (voltage, frequency) and communication facilities			B
5. Places for procurement of potable water, foodstuff, fuel, etc. in the case of camping at the work site, as well as routes for their transportation and means of transportation			B
6. Epidemics and local diseases			B
7. Nearby hospitals	- Address, equipment/facilities, etc.		B

Item	Description	Availability	Remark
8. Local labor available	- Types of labor (ordinary labor, cook, driver, intepreter, etc.) - Laws and regulations pertaining to employment - Wages - How to employ local labor (procedures)		B
10. Transceivers	- Name of laws and regulations pertaining to the matter - Authorities with jurisdiction on the matter - How to obtain authorization for use		B
11. Labor	- Labor laws and regulations - Holidays and days off - Daily working hours - Additional wages when working on holidays, days off and overtime		B
12. Land and forest protection	- Authorization to enter and survey private land - Authorization for felling for the purposes of the survey		B

Item	Description	Availability	Remark
13. Protection of fur and feather	- Types of fur and feather subject to protection - Protection areas		B
14. Available equipment	- Type, Number, storage place, new or used year, rent, owner and others	Available (Refer to next page)	A

List of Available Equipment

Item	Name of Equipment	Maker & Type	Number	Storage Place	Condition New/Used Y.	Owner	Rent	Other
For Topographic Survey	Transit	——	—					
	Level	Swiss	10					Most of the instruments are used by NEA
	Theodolite	Swiss	12	NEA	Used	NEA		
	Distance meter	Fusikoh	1					
	Altimeter	Swiss	4					
	Aero-photo glasses		1					
For Geological Investigation	Core drilling machine		9					
	Water-test pump		3	NEA	Used	NEA		
	Phisical seismic instrument	Terialoc. MK-II	1					
	Drifter for adit		—					
	Ground water meter		—					
For Construction Material Survey	Sieving instrument			SRCL		SRCL		
	Aggregate test instru.	Various	6	NEA	Excellent	NEA		Affirmative
For Meteorological and Hydrological Investigation	Pluviometer							
	Evaporating disk							
	Temperature recorder							
	Humidity recorder							
	Water level recorder							
	Water sampler							
	Turbid meter							

Ⅶ－2　収集資料

調査団が現地にて収集した資料リストは添付のとおりである。

収集資料リスト

番　号	資　料　の　名　称	版　型	ページ数	オリジナルコピーの別	部　数
1	年次報告書　91／92	A－4	39	オリジナル	1
2	既設・計画中発電所	A－4	1	コピー	1
3	既設水力発電所	A－4	1	コピー	1
4	電力開発地図	B－4	1	コピー	1
5	民間投資可能水力発電所リスト	B－4	3	コピー	1
6	イラム地区水力開発計画（図面）	A－4	1	コピー	1
7	イラム地区水力開発計画	A－4	1	コピー	1
8	イラム地区水力開発概要	A－4	21	コピー	1
9	送電線計画	A－4	2	コピー	1
10	7次電力計画（ｲﾗﾑ地区電化計画）	A－4	2	コピー	1
11	イラム・ジャパ配電計画図	A－3	1	コピー	1
12	132kV 、単線結線図	A－0	1	コピー	1
13	日負荷曲線	A－4	1	コピー	1
14	月負荷曲線	A－4	1	コピー	1
15	電力系統ピーク負荷図	A－4	1	コピー	1
16	系統負荷曲線	A－4	1	コピー	1

番　号	資　料　の　名　称	版　型	ページ数	オリジナルコピーの別	部　数
17	需要想定(1)	A－4	1	コピー	1
18	イラム地区需要想定	A－4	1	コピー	1
19	需要想定(2)	A－4	1	コピー	1
20	雨量観測記録	A－4	1	コピー	1
21	雨量観測記録（イラム地区）	A－4	14	コピー	1
22	ＮＥＡ人員リスト	A－4	1	コピー	1
23	ＮＥＡ保有器材表	A－4	1	コピー	1
24	イラム地区労務単価，建設資材単価	A－4	1	コピー	1
25	送電線建設単価	A－4	2	コピー	1
26	電気料金表 1991	A－4	10	コピー	1
27	地　図　$\frac{1}{500,000}$	A－1	3	オリジナル	1
28	地　図　$\frac{1}{50,000}$	A－1	4	コピー	1
29	地質図　$\frac{1}{250,000}$	A－0	1	オリジナル	1
30	土地利用図　$\frac{1}{50,000}$	A－1	1	オリジナル	1
31	イラム地区地図　$\frac{1}{125,000}$	A－1	1	オリジナル	1
32	水力開発政策	A－5	10	オリジナル	1

付　　録

要　請　書

MINISTRY OF FOREIGN AFFAIRS
His Majesty's Government of Nepal
Kathmandu

NEA/72-2/ISHD/9519

The Ministry of Foreign Affairs, His Majesty's Government of Nepal presents its compliments to the Embassy of Japan in Kathmandu and with reference to the discussions held in October 1991 with Japanese O.D.A. Mission in Nepal regarding the feasibility study of Ilam Small Hydropower Development Project has the honour to forward herewith a project-proposal of the same for the kind consideration of the Government of Japan.

The Ministry of Foreign Affairs avails itself of this opportunity to renew to the Embassy of Japan the assurances of its highest consideration.

Kathmandu, April 5, 1992.

His Majesty's Govt.
Ministry of Foreign Affairs

The Embassy of Japan,
KATHMANDU.

Encl: Two copies.

在ネパール日本国大使館 接受
APR - 8 1992
RECEIVED
Embassy of Japan, Nepal

NEPAL ELECTRICITY AUTHORITY

SMALL HYDRO PROJECT DEPARTMENT

A PROPOSAL OF ILAM SMALL HYDROPOWER DEVELOPMENT PROJECT

Kathmandu

January 1991

C O N T E N T S

Location Map

Photo Picture of Project Area

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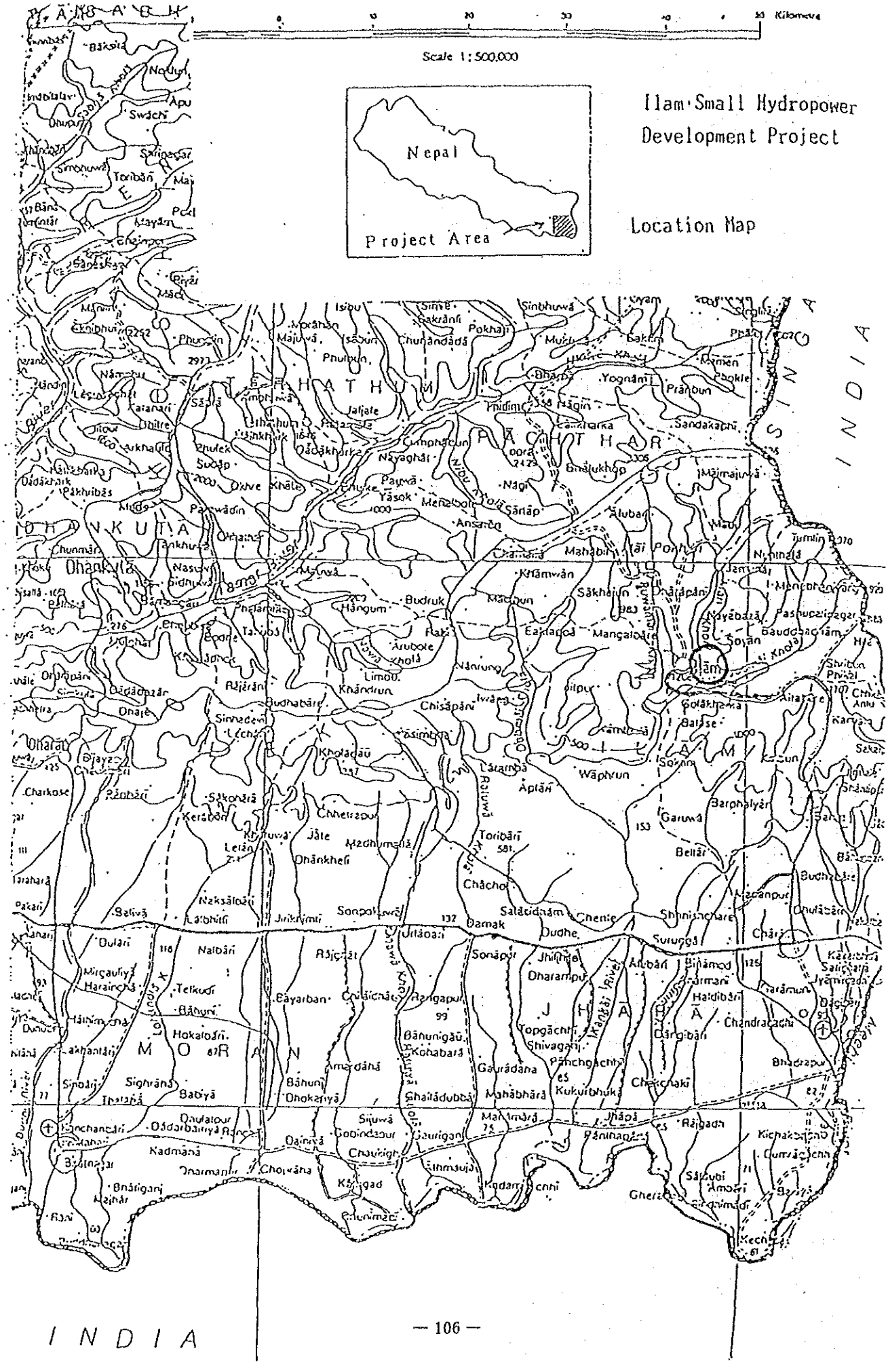
Appendix Tables & Figures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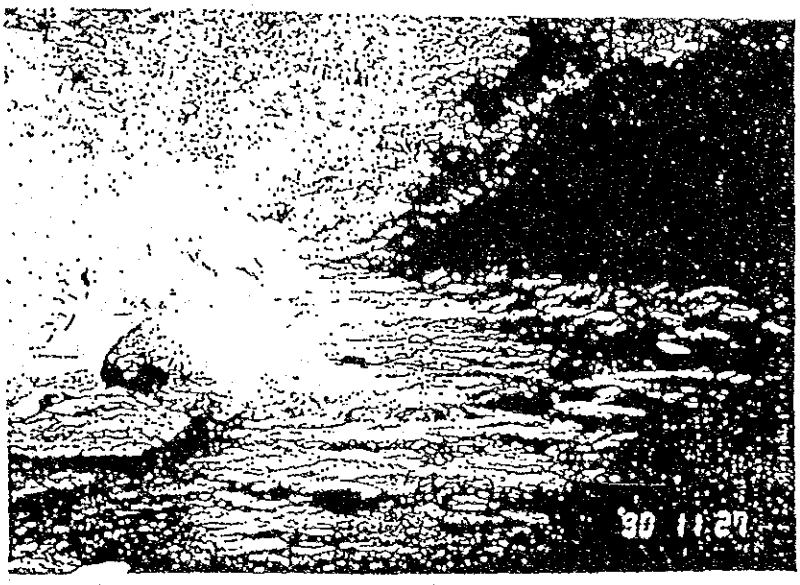
Nepal
Project Area
Ilam Small Hydropower
Development Project
Location Map
INDIA
INDIA
PANCHTHAR
TEHRATHUM
MORANG
JHAPA
ILAM

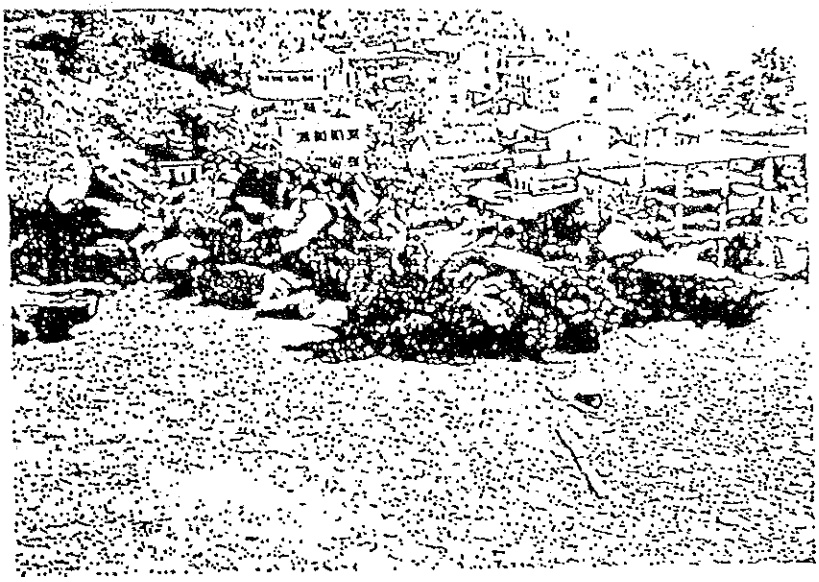


Puwa Khola Intake site(A & C plan)

Puwa Khola Intake site(B plan)

Suspension Bridge near to A & C Plan Intake site

Suspension Bridge near to B plan Intake site



Fuelwoods and Ham Bazar town

Penstock line site

ILAM SMALL HYDROPOWER DEVELOPMENT PROJECT

1. PROJECT BACKGROUND AND OBJECTIVE:

The 7th National economic development plan aims at:

*accelerated expansion of production
* generation of employment opportunities of good productivity
* meeting of minimum basic needs of the population

Development strategy to achieve these goals is as follows:

* Priority to development in the agriculture sector
* Rational development of forest resources and protection against soil erosion
* Water resources, industry and tourism development, and promotion of exports
* population control
* Rationalization of economic management through regionalized delegation of authority

Increasing of power supply is one of the most important points to promote above mentioned plan.

In the last 10 years, power supply has been greatly improved as a result of the power development projects mainly in the central region of Nepal as indicated below:

MAJOR POWER DEVELOPMENT PROJECTS IN THE LAST 10 YEARS:

* 1982 : No. 1 P/S at Kulekhani, 60,000KW (Completed)
* 1987 : No. 2 P/S at Kulekhani, 32,000KW (Completed)
* 1989 : Marsyandi P/S, 69,000KW (Completed)

Installed capacity in the country as of 1990 is 230,463 KW of hydropower, and 28,683 KW of diesel for a total of 259,683 KW. However, power supply still runs short and can not meet basic demand.

The HV transmission grid has been steadily expanded. With construction of the transmission line indicated below, power feed to major rural cities outside Kathmandu has become possible since 1985. However, there are only very limited plans within this to extend transmission lines this century into the hill areas comprising 85% of Nepal.

TRANSMISSION LINE PROJECT SINCE 1985:

* 1987: Hetauda - Biratnagar, 250 Km, 132kv, 1 line
* 1989: Marsyandi - Kathmandu, 110 Km, 132kv, 1 line
* 1990: Biratnagar - Anarmani, 78 Km, 132kv, 1 line
* 1990: Shivpur - Nepalgunj, 147 Km, 132kv, 1 line

As indicated above, rural areas not connected with national grid remain extremely backward, particularly standards of living and education due to a lack of electricity.

In Nepal, 85% of the country is rugged hill and mountain area with little transportation infrastructure. Of the 75 districts in the country, 27 are connected to the national grid. In 24 districts, headquaters are serviced by extremely small-scale hydropower schemes or diesel generators (50 - 200 kW) providing power for lighting only.The reamining 24 districts are unelectrified.

In the meantime, Ilam district is located in the far eastern part of Nepal adjacent to the Indain border. The district headquater of Ilam bazar is the administrative center of the district, which HMG is eager to further develop as one of industrial towns in Nepal. Thus, Ilam district is scheduled to be connected with national grid by 1995 according to the 7th Power Project (ADB).

However, it is anticipated that large-scale project like "ARUN 3" may be delayed in schedule due to various reasons, and power supply to the district may not be possible for the lack of power supply capacity even after national grid system has been completed.

Under the circumstance, development of Ilam small hydro plan of 5,000 kW (more than 2% of total installed capacity of hydropower) using the potential of Puwa Khola near the Ilam bazar and connecting to the national grid will make a significant contribution to local development of Ilam area and also stable power supply in the east area.

In view of the above, we would like to carry out an immediate Feasibility Study to promote this project under Japanese Grant Aid.

2. GENERAL ON ILAM DISTRICT:

(1) General

- Ilam district is located in the far eastern part of Nepal adjacent to the Indian border. Administratively, it belongs to the Mechi zone of the Eastern Development Region.
- The district is hill area, 1,703 km^2 in size, and with elevation ranging EL 610 ~ 3,679 m. Annual precipitation is 1,700mm; mean maximum temperature per month is 21.8°; mean minimum temperature per month is 12.7°.
- Population according the the 1981 census was 178,356. Estimated population in 1990 is 231,281. Population density is 135/km^2.
- The district headquarter of Ilam Bazar is the administrative center of the district, and has a population of 12,000. The town has historically served as a relay point for traffic between the Terai plain and the high Himalayas, and has thrived as well as a center for trade from the Darjeeling region in the neighboring Indian state of West Bengal.
- The district is famous for the production of Ilam tea. Farm and livestock production as shown below is also widespread.

	Farm Products		Livestock Products	
	Cultivated area	Product		Nos.
Paddy	12,400 ha	21,340 ton	Cattle	73,487
Maize	15,200 ha	26,620 ton	Buffalo	19,984
Wheat	3,950 ha	4,340 ton	Sheep	6,208
Millet	2,680 ha	2,510 ton	Goats	72,547
Potato	3,520 ha	20,200 ton	Swine	11,189
			Fowl	129,826

(2) Ilam Tea

- Production of tea in Nepal in 1988/89 was 1,346,600 kg. The majority of this was produced in Ilam and Jhapa districts in eastern Nepal.
- Of the above total, 523,000kg was produced by the Nepal Tea Development Corporation (NTDC). The remaining 823,600 kg was produced in the private sector.
- However. total domestic tea production is equivalent to only 33% of consumption. Accordingly, the government is promoting the expanded production of tea.
- Constraints to increased tea production are (i) the need to improve technical levels of cultivation, (ii), wood fuel shortages, (iii) lack of irrigation facilities, (iv) lack of development funding, etc.
- NTDC tea plantations and tea processing plant capacities are as shown below.

	Total Granted Area (ac)	Tea Garden Area (ac)	Tea Plant Capacity (kg/year)
Ilam district			
① Ilam Estate	135	120	40,000
② Kanyn E.	530	460	200,000
③ Soktim E.	240	180	80,000
④ Chilinkot E.	1,000	106	--
Jhapa District			
① Burne E.	2,000	704	--
② Baradasi E.	384	32	--
③ Tokla E.	724	628	400,000
Total	5,012	2,230	

* Ilam estate is the oldest tea planatation in Nepal, having been established 127 years ago. Next oldest is Soktim estate begun 30 years ago.

* Estates requiring the most urgent further development are Chilinkot and Burne. For such development, lift irrigation from nearby river is necessary. Necessary capacity at 1 lift irrigation location is estimated at 20,000 m^3/day, to be lifted 100 m. This would require a power sources of 300 Kw.

* Tea processing plants currently use wood as energy source for boiler and drying. 4 kg of fuel wood is consumed per 1 kg of processed tea. It is becoming increasingly more difficult to obtain required fuel wood due to over-cutting of forests in the environs. To address this, NTDC is considering options of development of fuel wood forest, and development of small dydropower.

35,000 kg of processed tea was produced at the Ilam plant in 1989. Fuel wood consumption was 140 tons. The power source at the plant consists of 2 diesel generating units of 50 kVA and 15 kVA capacities, respectively.

(3) Power in Ilam District

The following power generating facilities exist in Ilam district.

① Ilam diesel plant (245 kW capacity serving Ilam Bazar)

② Gorkhe main hydro (64 kW capacity serving Gorkhe, Pashupatinagar)

Ilam diesel plant supplies power via 220 V distribution line to 333 households in the district headquarters of Ilam Bazar (population: 12,000). Electrification rate for Ilam Bazar is 15%.

Facilities at the Ilam diesel plant are superannuated, having been in operation for over 20 years. Recent maximum output is only 170 kW. Average operation is only for 4 hours in the evening (17:30 ~ 21:30), at 150 kW output.

Most supplied power goes to commercial and industrial enterprises including stores, hotels and cottage industries. Very little power is directed to households.

Another problem is posed by the sharp rise in the cost of high speed diesel oil used at the Ilam diesel plant. The situation with regards to this is as follows:

a. Fuel Consumption per Month

280 ℓ of oil is burned per 1 day of operation at 150 kW output for 4 hours. Consumption per month is thus 9,000 ℓ / month. At Rs 10 / ℓ, monthly expenditure for fuel is:

$$9{,}000\ \ell/\text{month} \times \text{Rs}\ 10/\ell = \text{Rs}\ 90{,}000/\text{month}$$

b. Generated Power and Revenue

Generated power:	150 kW × 4 hr × 30 days = 18,000 kWH / month
Power tariff:	Rs 1.1 / kWH (uniform throughout Nepal)
Revenue:	Rs 19,800 / month

In other words, income of Rs 1.1 / kWH is obtained on Rs 5 / kWH expenditure (this includes only for diesel fuel). In addition to fuel, operating costs for staff (5 persons), lubricants, etc. are also necessary. These others are estimated at Rs 10 / kWH.

In light of the above, small hydropower is highly desirable as an inexpensive, alternate source of energy.

3. POWER DEMAND IN ILAM DISTRICT

(1) Power Demand Area

The following two areas are selected as power demand areas:

a. 10 km Radius around Ilam Bazar

A 10 km radius around Ilam Bazar, the most densely populated area in Ilam district, would encompass an area with population estimated at 78,500 and average population density of 250 persons / km^2 (population density as of 1990 for the entire district is 135 persons / km^2). The said area (314 km^2) would account for about 18.5% of the total area of the district.

Candidate site for a small hydropower scheme for the area would be about 2.5 km south of Ilam Bazar.

b. Soktim/Chilinkot Tea Estate

This area is located slightly away from the above area. The NTDC Soktim Tea Estate is about 5 km south of the candidate site for the small hydropower scheme.

Soktim Tea Estate was established about 30 years ago. The estate's tea processing plant produces 80,000 kg per year. Chilinkot Tea Estate was begun 10 years ago, but as of yet only 106 ac of a total planned 1,000 ac have been developed.

Current NTDC planning envisages the future merging of the Soktim and Chilinkot estates, dismantling of the superannuated tea processing facilities at Soktim and construction of a modern tea factory at Chilinkot.

In order to realize this plan, lift irrigation from nearby river and inexpensive power source for plant modernization will be required.

(2) Power Demand Forecast

a. Domestic Demand

There are 11 villages of population more than 3,000 in the 10 km radius area around Ilam. At present, only one very small portion of Ilam Bazar (333 households) is electrified by Ilam diesel plan (245 kW). Power supply is for only 4 hours at night (17:30~21:30). Consumption per household is:

150 kW / 333 households = 450 W / household

If a stable supply of electricity by small hydropower scheme were available 24 hours per day, demand can be expected to increase sharply as such supply would enable the use of electrical appliances in the home such as television, refrigerator, heater, range, etc.

Ilam Bazar has historically been a trade center for the hill area of eastern Nepal. It has the functions of a major town, being the site of about 100 stores, 10 hostels and lodges, branch offices of various agencies of the central government, a primary school, middle school, college and hospital. The various facilities of the Ilam Tea Garden (factory, office, guest house, etc.) are also located in Ilam Bazar. Several rice and wood mills are also situated in the area.

Accordingly, we estimate projected domestic power demand in kWs for the area is presented in the next page.

PROJECTED DOMESTIC POWER DEMAND IN 10 KM RADIUS AREA

	Estimated Population in 1990	Households	1995			
			Electrification rate	Electrified Households	Power per Household (kw)	Power Demand (kw)
1. Ilam Bazar	12,000	2,182	30	655	0.5	328
2. Singring	7,000	1,273	15	191	0.3	57
3. Gola Khalka	7,000	1,273	15	191	0.3	57
4. Thulo Godak	7,000	1,273	15	191	0.3	57
5. Sukrabare Bazar	5,000	909	15	136	0.3	41
6. Namsling	5,000	909	15	136	0.3	41
7. Maibani	5,000	909	15	136	0.3	41
8. Soyang	3,000	545	10	55	0.3	17
9. Barbote	3,000	545	10	55	0.3	17
10. Phuluk	3,000	545	10	55	0.3	17
11. Sangrumba	3,000	545	10	55	0.3	17
12. Other areas	18,500	3,364	5	168	0.3	50
Total	78,500	14,272		2,079		740

Projected domestic demands assuming power demand growth rate of 10% per year:

1995	740 kW
2000	1,192 kW
2005	1,919 kW
2010	3,091 kW
2015	4,978 kW

	100	50	110	77	120	120	135	140	160	185	170	200
[illegible]	10	10	12	12	16	20	16	26	16	30	15	30
[illegible]	1	--	1	2	1	3	1	4	1	5	1	5
[illegible] offices, bank,	5	--	5	5	5	5	5	5	5	5	5	5
[illegible]pital	2	--	2	2	3	5	3	7	3	10	3	10
[illegible]o relay station	1	(10)	1	10	1	10	1	15	1	20	1	20
[illegible] mill	5	(25)	5	25	5	25	5	30	5	30	5	30
[illegible] chilling plant	2	(70)	2	70	2	70	3	100	3	100	3	100
[illegible]d mill	5	--	5	25	5	25	5	30	5	30	5	50
[illegible]all pump [illegible]ion	--	--	3	10	3	10	4	15	5	20	5	20
[illegible] factory	2	(300)	2	500	3	500	3	1,200	3	1,500	3	2,000
Total	--	160 (405)	--	1,483	--	1,990	--	3,497	--	5,016	--	7,458

Note:

① Figures in parentheses indicate capacity of in private power facility. Power supply would be from small hydropower scheme after its completion.

② See previous section for domestic power demand.

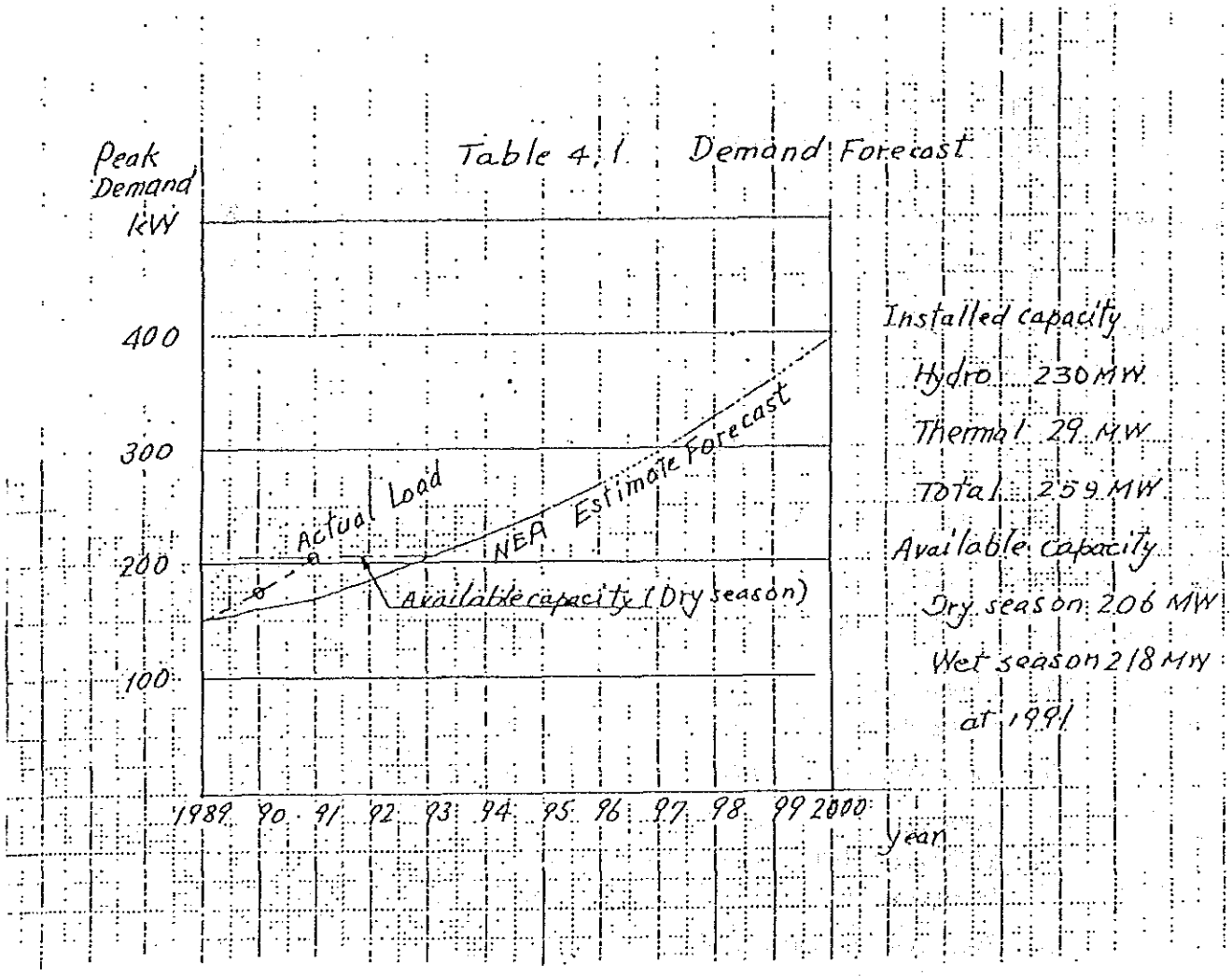
③ In the case of tea estates (Ilam, Soktim), lift irrigation (200 kW) is assumed for Chilinkot in 1995, a new factory at Chilinkot in 2000, and rehabilitation of Ilam factory in 2010.

④ Small pump station is for lift of water from well or river for potable water and irrigation.

4. POWER DEMAND AND SUPPLY IN NEPAL:

Demand forecast as indicated in Table 4.1 is expected to drastically increase in line with extention of the national grid.

However, since estimated commissioning date for the ARUN-III power project (400 MW) currently under construction has been moved back from 1995 to 2000, forthcoming rural electrification development is feared to delay. If Ilam small hydropower project is completed by 1995, projected national grid under seventh power project (ADB) will become more significant. Generating power in Ilam power station will be utilized to full extent.



5. ILAM SMALL HYDROPOWER SCHEME:

(1) Location

The small hydropower scheme envisaged would generate using discharge diverted from the Puwa khola to the Mai khola, which flows 2.2 km to the west of Ilam Bazar. Ilam Bazar is the district headquarters for Ilam district in Mechi zone in far eastern Nepal.

Ilam Bazar is located on the Maharabat range at elevation EL 1,000 m. It can be reached by unpaved road (7 m width) running 78 km north from Charal on the Terai plain east–west highway.

(2) Climate, Population, Industry

Annual mean temperature at Ilam Bazar is 19°C. Maximum temperature in the summer is 30°C, and the minimum in the winter is 5°C. Annual precipitation is 1,500~1,600 mm, concentrated in the rainy season from mid April to mid October. A small amount of rainfall also occurs in the dry season extending from November to March.

Population of Ilam district is 230,000, comprising 41,800 households. Land area is 1,703 km^2. Population density for the district as a whole is 135 persons / km^2. Population density is greatest in the 10 km radius area around Ilam Bazar (estimated at 250 persons / km^2).

Main industries are farming, animal husbandry, forestry and tea manufacture. Particularly well known is Ilam tea, closely resembling Darjeeling tea of nearby India.

(3) Rivers

The Puwa khola with headwaters in the EL 3,000 m Maharabat range flows southward about 30 km to its confluence with Mai Khola 5 km south of Ilam Bazar.

Rainfall is relatively abundant in the Ilam region, making the area suitable for tea cultivation. Discharge of the Puwa khola is likewise abundant, with annual mean of 6.65 m^3 / 100 km^2. 90% probable discharge is 0.89 m^3/s.

The Puwa khola is characterized by steep river gradient in excess of 1/20, and is well suited to small hydropower development. Since the river gradient of the Mai khola, which flows into the Puwa khola west of Ilam Bazar, is relatively gradual, elevation differential of 150 m exists between the beds of the two rivers where the Mai khola flows along the east side of

the Puwa. Accordingly, diversion from the Puwa to Mai khola by 2.7 km tunnel would achieve about 300 m of head.

(4) Assumed Preconditions for Power Development Plan

a. Upstream Irrigation Plan

The Department of Irrigation of the Ministry of Water Resources has been implementing the Puwa Khola Irrigation Project at the upstream reaches of the Puwa khola since 1989. Basic features of this project are as follows:

Diversion level: EL 1,185 m (EL 3,877 ft)

Diversion catchment area: 68.3 km^2 (diversion point: 26°54'15"N / 87°54'02"E)

Maximum diverted discharge: 1.1m^3/s (perennial)

Irrigated area: 450 ha

Headrace length: 21 km

Construction cost: Rs 10.6 million (1985 prices)

However, very little progress on the project has been achieved as of December 1990 due to budget inadequacies (progress rate to date is 1~2%). Construction cost in 1990 prices has swelled to Rs 21 million. Project budget for 1990/91 was only Rs 200,000, or 1% of project cost.

As a result, completion date for the Puwa Khola Irrigation Project it assumed to be 2000 for planning under the subject small hydropower development.

In other words, for the 5 year period from proposed completion of the small hydropower scheme in 1995 to completion of the Puwa Khola Irrigation Project in 2000, the entire discharge of the catchment is available for power generation. However, from 2001, planning must assume an elimination of under 1.1 m^3 of discharge of the 68.3 km^2 irrigation diversion catchment.

b. Connection to National Grid

The national grid was greatly expanded in the 1980's. In 1987, a 132 kV transmission line was completed for 700 km between Kohalpur near Nepalganj in the west to Anarmani in the east. This connected with the main power stations at

Kulekhani I and II (92 MW) and Marsyangdi (66 MW), and providing 80% of the Terai plain with power.

Service from the above east~west 132 kV transmission line to major towns along its route is currently being pursued since 1986 under ADB finance (fifth~seventh power projects).

* If Ilam hydropower project proceeds as scheduled, the national grid extention under seventh power project (ADB) will be completed by 1995 as initially planned.

Anarmani substation at the eastern most extremity of the national grid is 80 km south of Ilam Bazar. The environs of the substation have been electrified from about 2 years ago; however, due to location at the terminus of the grid, voltage fluctuation is marked and blackouts are frequent.

(5) Objective of Small Hydropower Development

a. Small hydropower development will contribute significantly to electrification of the 10 km radius area of high population density around Ilam Bazar.

b. The small hydropower scheme envisaged will be ultimately connected with the national grid around 1995, contributing to the stable supply of power in the eastern Nepal region.

c. The small hydropower scheme would be connected with existing diesel generating facilities (600 kw) around Ilam Bazar. Shift would be to small hydro as principal power source, backed up by diesel generation. This would greatly reduce the cost of power.

d. Electrification by small hydropower would reduce use of fuel wood for energy, thereby contributing to preservation of the natural environment.

(6) BASIC APPROACH TO SMALL HYDROPOWER DEVELOPMENT

a. Operation of the small hydropower scheme would commence in 1995. Power demand in 1995 is forecast at 1,500 KW, to increase to 2000 kW by 2000 in Ilam area. By 1995 Ilam will be connected to national grid. So, surplus power generated can be transffered to national grid.

b. It is assumed that the Puwa Khola Irrigation Project will be completed by 2000. As a result, 1.1m^3/s of discharge from 68.3 km^2 within the catchment will no longer be available.

c. The small hydropower scheme would be absorbed into a larger, regional power supply system with connection to the national grid in 1995. Consequently, small hydropower development would aim at the optimum economical scale for 1995.

d. Three conceivable development options are given below: (see Fig - 4)

A PLAN: diversion water level - EL 2,500 ft
tailrace water level - EL 1,500 ft
Capacity - 5,000 kW

B PLAN: diversion water level - EL 2,000 ft
tailrace water level - EL 1,400 ft
Capacity - 3,140 kW

C PLAN: diversion water level - EL 2,500 ft
tailrace water level - EL 2,050 ft
Capacity - 2,160 kW

(7) Salient Features

	Unit	A PLAN		B PLAN		C PLAN	B + C PLAN
		to 2000	after 2001	to 2000	after 2001	after 2001	after 2001
Intake water level	El m	2,500	2,500	2,000	2,000	2,500	
Tailrace water level	El m	1,500	1,500	1,400	1,400	2,050	
Catchment area	Km^2	125	56.7 (+68.3)*3	130	61.7 (+68.3)*3	56.7 (+68.3)*3	
Maximum generating discharge	m^3/s	2.06	2.06	2.14	2.14	2.06	
Effective head	m	298	298	178	178	133	
Maximum output	kW	5,000	5,000	3,010	*1 3,010	*2 2160	*1-2 5170
Firm output	kW	2,500	1,180	1,490	*1 740	*2 510	*1-2 1250
Annual generated energy	MWH	38100	30000	22900	*1 16000	*2 12900	*1-2 28900
Firm generated energy	MWH	20800	9,700	12,500	*1 6,200	*2 4,200	*1-2 10,400
Facility use rate	%	87	68	87	68	68	68
Tunnel length	m	2,700	2,700	1,200	1,200	2,400	
Construction Cost	$10^3$$	7,870	7,870	*1 5,490	5,490	*2 4,780	*1-2 10270
(Yen Conversion)	(10^6¥)	(1,024)	(1,024)	(714)	(714)	(621)	(1,335)
Generating unit Cost		0.031	0.039	0.036	0.051	0.056	0.053
B/C		1.66	1,25	1.43	0.96	0.88	0.92

*3) intake catchment at upstream irrigation

c. Points of Note regarding Development Features

① Design features at this stage are very preliminary figures base on 1/50,000 topo-map and monthly mean discharge records for Puwa Khola Station for 1965~68.

② Annual generated energy is assumed at 95% of total possible power generation per year (shutdown loss: 5%).

③ Construction cost adopts average unit prices prevailing in the Southeast Asian region in recent years.

④ Annual running cost for computation of energy cost is assumed at 15% of construction cost.

⑤ B/C calculation for A plan applies 10 MW diesel generation as the alternative power source. Cost of diesel is assumed at US$ 23/bbl.

(8) FEATURES ON ILAM SMALL HYDROPOWER PROJECT:

1) The envisaged small hydropower development is both economically and technically attractive. The development site is proximate to the intended power market.

2) A daily load factor of 60~70% can be expected, with demand emerging not only for lighting, but also operating power for agro-industries such as tea factory, rice mill, wood mill, etc.

3) The Ilam area is located in far eastern Nepal, over 500 km from existing generating facilities at Kulekhani and Marsyangdi. It is likewise 400 km by transmission route from the Arun -III scheme currently under construction.

Accordingly, even with connection of the Ilam area to the national grid the envisaged small hydropower development will make a significant contribution to stable power supply in the area.

4) The population density in the 10 km radius area around Ilam is high. Heavy consumption of fuel wood has depleted forests in the environs, and residents must now travel long distances at great exertion to obtain fuel wood. Electrification under the Ilam small hydropower scheme will reduce the need to consume fuel wood.

5) The NEA Ilam diesel plant (245 kW) fails to meet general demand in the area. Furthermore, operation costs are in the red with current fuel cost at Rs 10/ℓ or US¢ 33/ℓ(generating cost: Rs 6/kWH or US$ 0.2/kWH)

6) Since the subject preliminary Study was of short duration, a number of assumed conditions were adopted as criteria in power demand forecast and plan formulation. Nevertheless, the attractiveness of the proposed development is clear and it is recommended that feasibility study be implemented as soon as possible to more precisely confirm economic and technical aspects.

6. PROPOSAL FOR FEASIBILITY STUDY

1) Study Objective

To carry out a feasibility study for small hydropower development to supply electricity to Ilam district in Mechi zone in eastern Nepal.

2) Study Period

One year from October 1991 to September 1992.

3) Executing Agency

The feasibility study would be carried out under technical cooperation of the Japan International Cooperation Agency. Executing agency would be the Nepal Electricity Authority of HMG.

4) Study Components

a. General data collection, collation and analysis

- Socio-economic data for Nepal in general and Ilam district in detail
- Various HMG development planning
- Power development agencies and budgets
- Long term power development plans, particularly for rural electrification

b. Collection, collation and analysis of power demand data

- Power demand in Nepal as a whole
- Power demand forecast for Ilam area
- Relationship to ADB Seventh Power Project
- Power supply area for small hydro development

c. Collection, collation and analysis of small hydropower development data

- Meteorologic and hydrologic data
- Topographic and geologic data

-- Construction cost data

d. Field survey

-- Site selection by surface reconnaissance

-- Geologic and environmental impact survey by surface reconnaissance

-- Topographic survey: 1/200~1/500 scale for structure sites

-- Geological survey: electric prospecting and test drilling at diversion weir, tunnel, penstock route and power station sites

-- Discharge gauging and analysis

-- Sedimentation estimate

e. Plan formulation

-- Formulation of several scheme options

-- Selection of optimum scheme

-- Formulation of transmission and substation plan

-- Formulation of construction work plan

f. Project evaluation

-- Economic and financial analyses

-- Socio-economic impact study

-- Environmental impact study

-- Overall project evaluation

g. Reports

-- Inception Report

-- Progress Report

-- Interim Report

-- Draft Final Report

-- Final Report

5) REQUIRED MANPOWER

1. Team Leader/ Hydropower Planning
2. Hydrologist/Meteorology, Silt-Analysis, Environment
3. Civil Engineer, Design, Cost Estimate, Material Survey
4. Electrical Engineer/Demand Forecast, E/M Design
5. Geologist/Geological Analysis
6. Economist/Socio & Economy Analysis, Financial Analysis
7. Drilling Expert/Supervision of Drilling works
8. Seismic Prospect Expert (2 persons)/Seismic Prospect Survey
9. Ground Topo Surveyor (2 persons)/Ground Survey

Appendix

Table A-1 Puwa Khola Monthly Mean Discharge

Gauging Station ; Puwa Khola G. S. (Lat 26° 55′ 00″ , long 87° 54′ 00″)
No. 730

Dranage area : 107km

Altitude : El 802m

Period of measurement : 1965 ~68

Unit: m'/s

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Mean
1 9 6 5	1.856	1.644	1.088	1.085	1.288	4.189	11.83	20.19	12.59	1.285	0.828	0.841	4.922
6 6	0.744	0.779	0.687	0.585	0.731	1.043	26.49	29.71	22.27	8.919	2.825	1.783	6.474
6 7	1.282	0.886	0.523	1.047	2.061	5.019	17.75	21.22	18.00	4.840	2.211	1.985	6.445
6 8	1.727	1.337	0.783	1.152	4.856	13.56	30.18	31.80	19.28	16.42	3.807	1.863	10.63
Average	1.402	1.162	0.768	0.967	2.234	5.952	21.56	25.73	18.04	7.866	2.418	1.618	7.118

(100squre kilometer : 6.65 m'/s)

Source ; Dept. of Hydrology and Meteorology, (DOHM) MWR, HMG

Note ; ① Puwa Khola G.S. had not been measured completely through a year during 1965~68, in which had been many lacking records of guage-height, DOHM had corrected on basis of record for nearby stream.

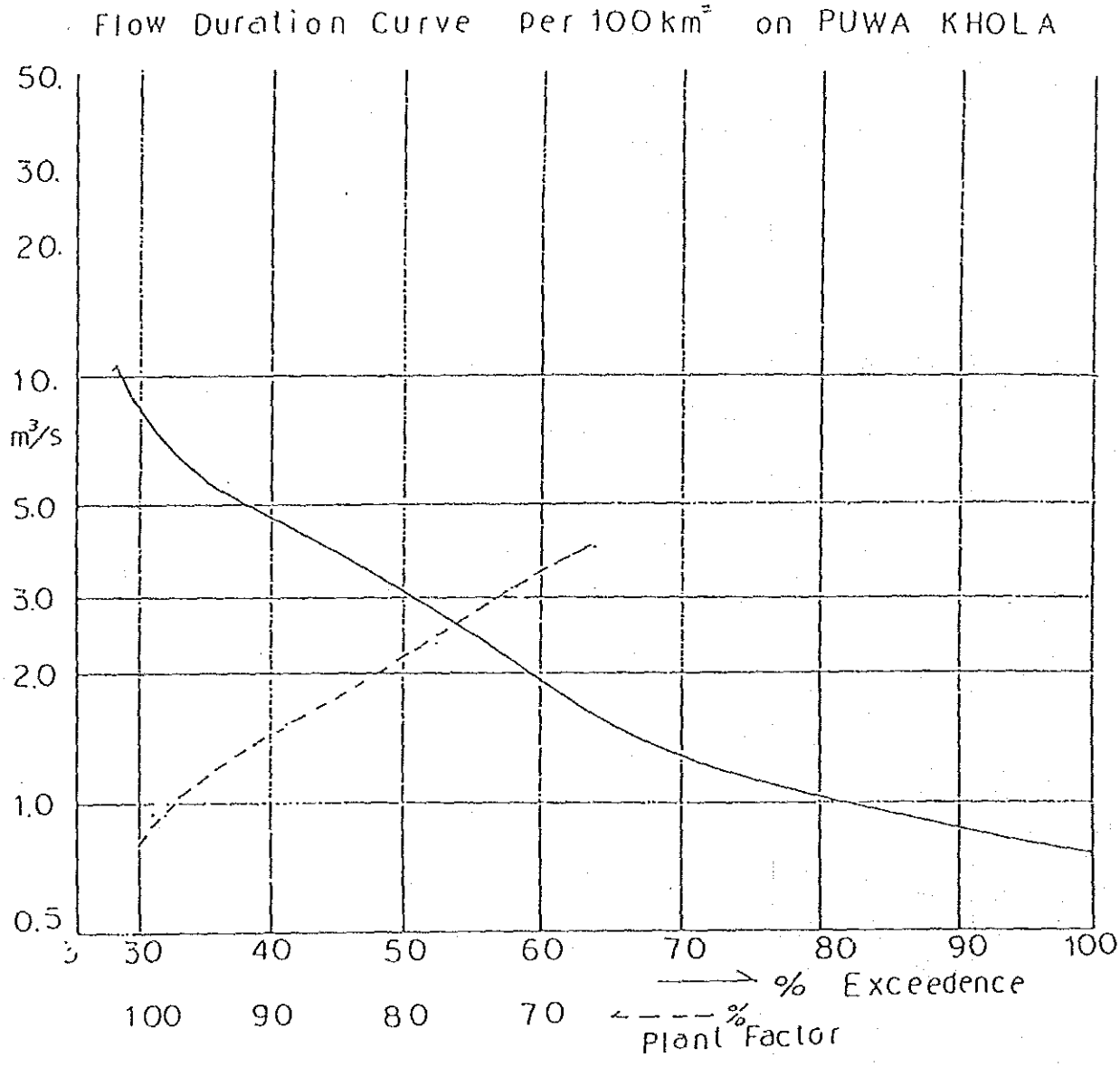
Appendix X

Table A-2 Rainfall in Catchment (1961～70 : Monthly average)

Unit: mm

Guaging Station	Elevation	Jan	Feb	Mar	Apr	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Memeng Jagat	1.829 m	16	13	45	107	277	366	532	446	274	148	24	02	2.251
Taplejung	1.768 m	16	39	61	88	225	348	452	432	267	67	15	05	2.015
Ilam Bazar	1.257 m	09	09	20	52	138	295	464	304	196	78	08	02	1.575

Fig-1 Duration Curve of Puwa Khola Discharge



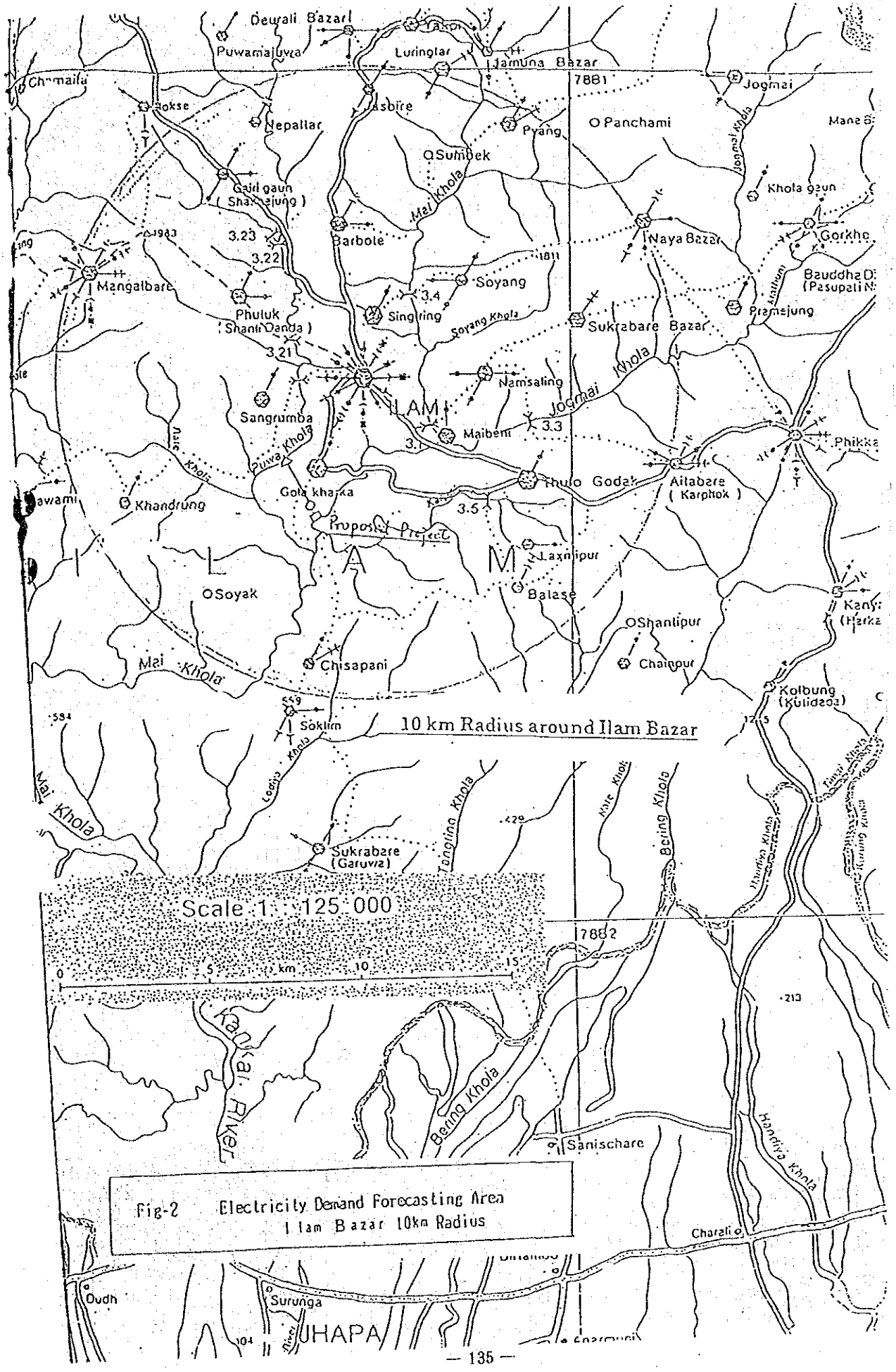


Fig-2 Electricity Demand Forecasting Area
Ilam Bazar 10km Radius

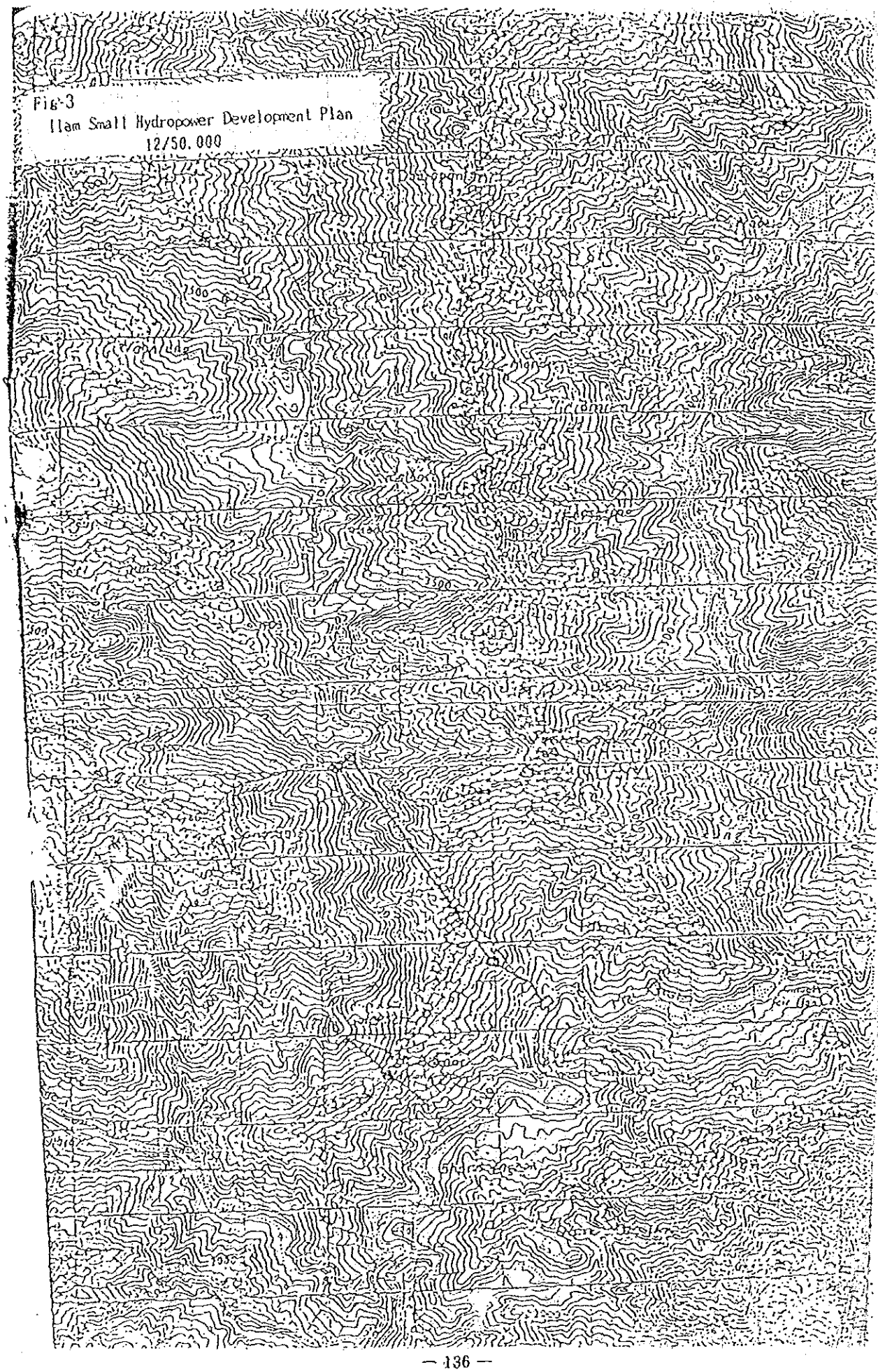
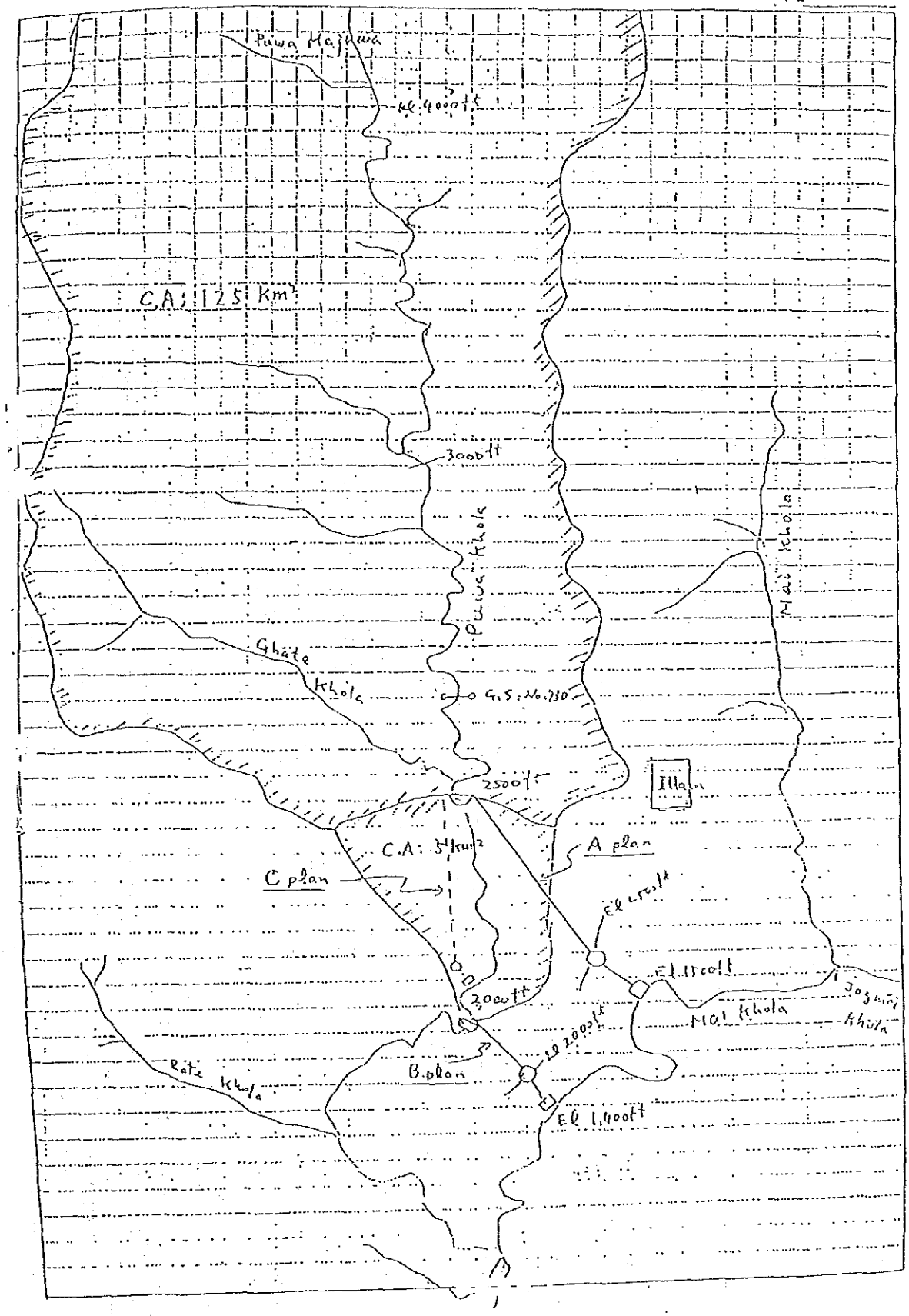


Fig-3
Ilam Small Hydropower Development Plan
12/50,000

Fig-4 Development Alternative Plan A~C



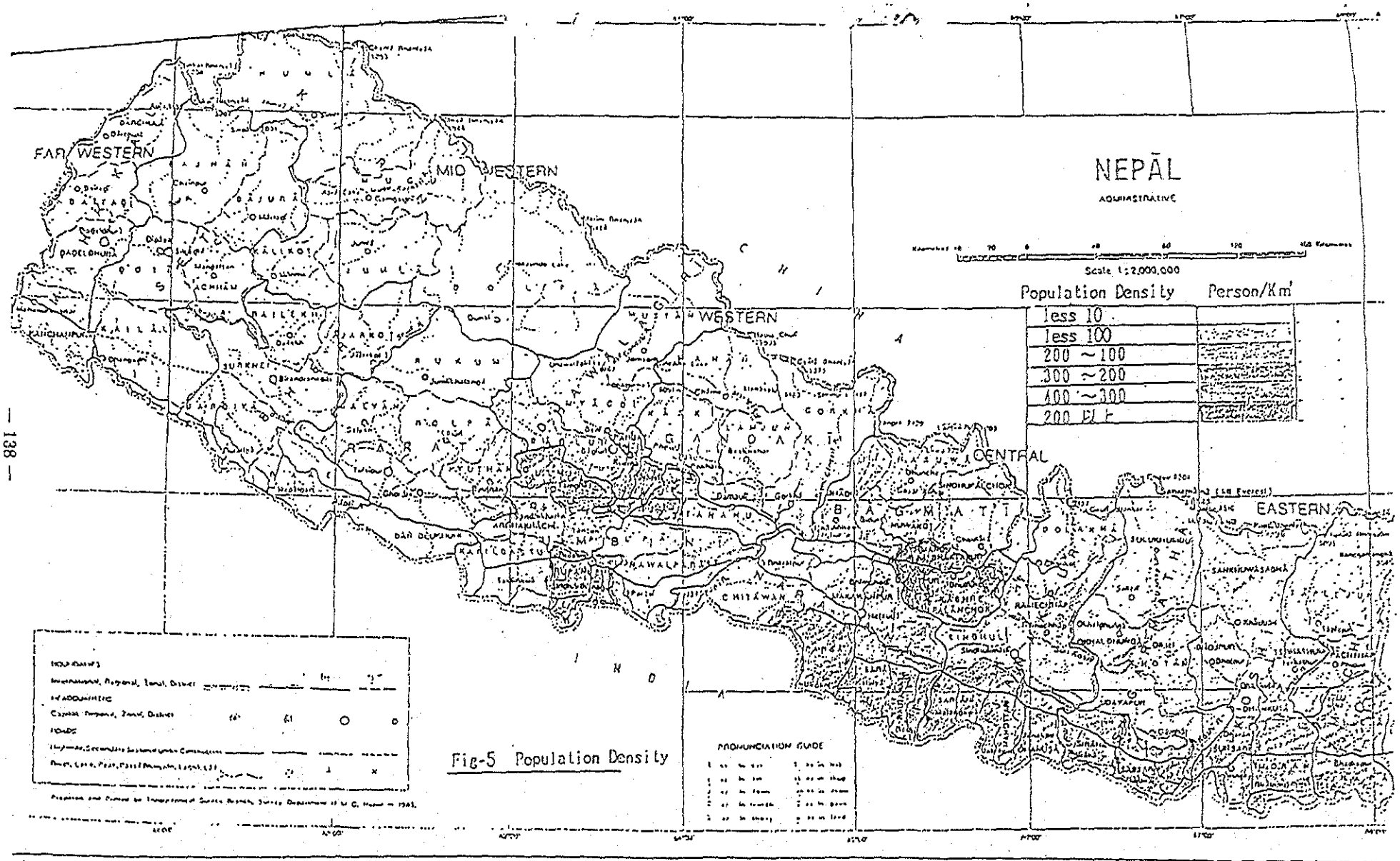


Fig-5 Population Density

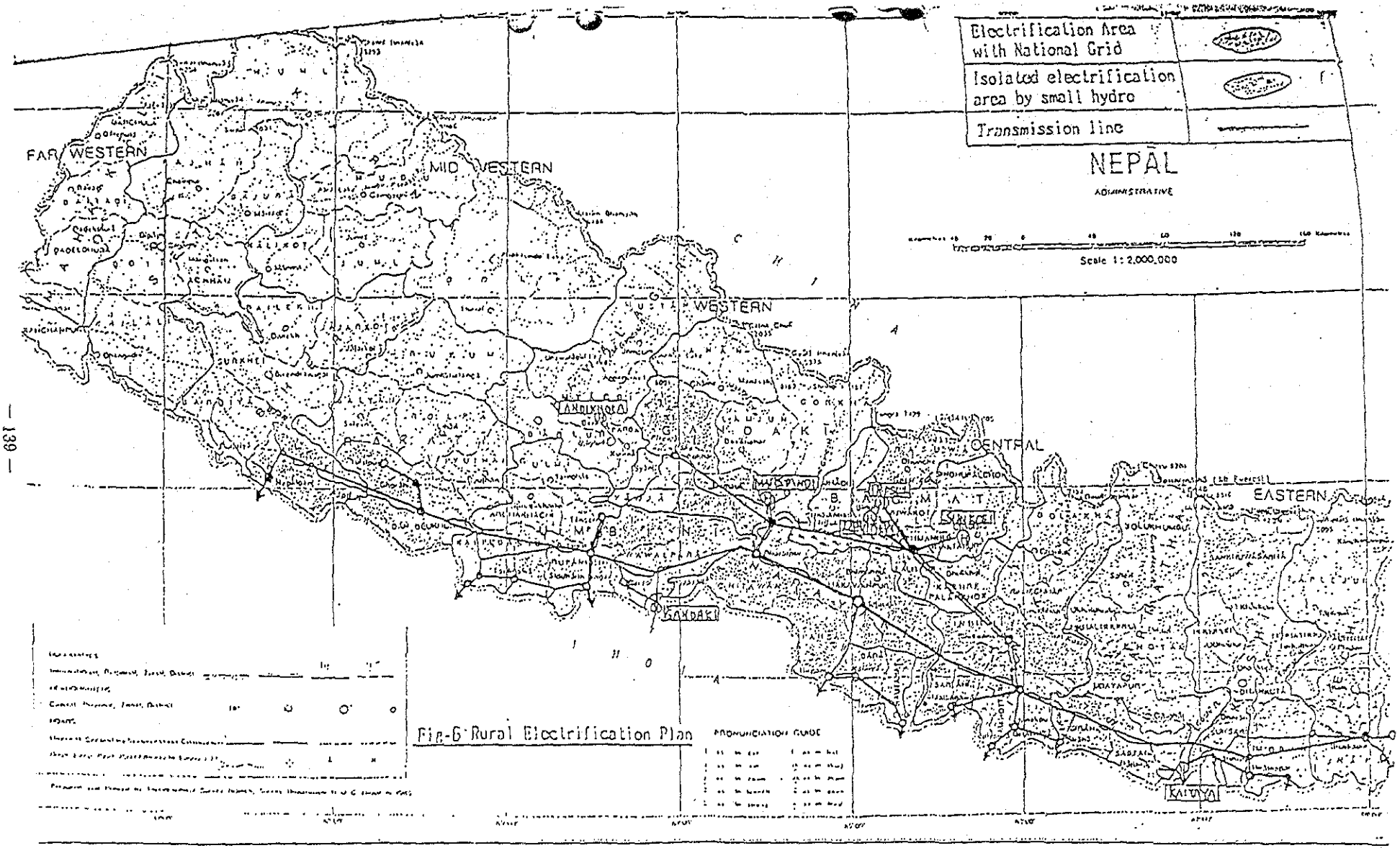
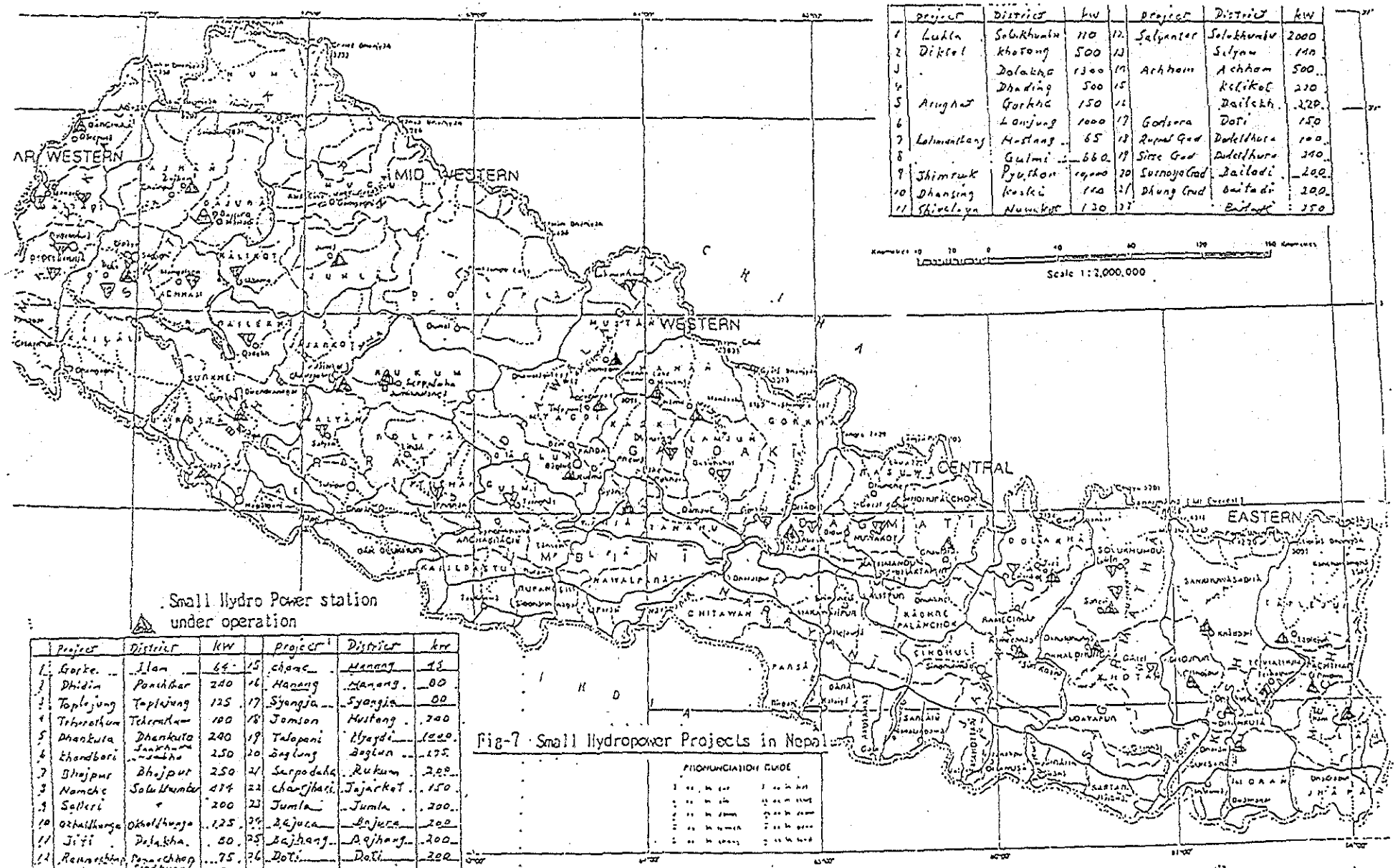


Fig-6 Rural Electrification Plan



	Project	District	kW		Project	District	kW
1	Lukla	Solukhumbu	110	12	Salpantar	Solukhumbu	2000
2	Dikkel	Khotang	500	13		Salyan	140
3		Dolakha	1300	14	Achham	Achham	500
4		Dhading	500	15		Kalikot	210
5	Arughat	Gorkha	150	16		Dailekh	220
6		Lamjung	1000	17	Gorsera	Doti	150
7	Lohamanthang	Mustang	65	18	Rupal Gad	Dadeldhura	100
8		Gulmi	660	19	Sitle Gad	Dadeldhura	240
9	Jhimruk	Pyuthan	1000	20	Surnaya Gad	Bajhang	200
10	Dhansing	Baglung	140	21	Dhung Gad	Baitadi	200
11	Shivalaya	Nuwakot	130	22		Baitadi	250

Small Hydro Power station
under operation

	Project	District	kW		Project	District	kw
1	Gorke	Ilam	64	15	chanc	Manang	15
2	Dhidim	Panchthar	240	16	Manang	Manang	80
3	Taplejung	Taplejung	125	17	Syangja	Syangja	80
4	Tehrathum	Tehrathum	100	18	Jomson	Mustang	240
5	Dhankuta	Dhankuta	240	19	Talapani	Myagdi	1200
6	Khandbari	Sankhuwa Sabha	250	20	Baglung	Baglung	175
7	Bhojpur	Bhojpur	250	21	Sarpodaha	Rukum	200
8	Namche	Solukhumbu	414	22	charjhari	Jajarkot	150
9	Salleri	"	200	23	Jumla	Jumla	200
10	Okhaldhunga	Okhaldhunga	125	24	Bajura	Bajura	200
11	Jiri	Dolakha	50	25	Bajhang	Bajhang	200
12	Ramechhap	Ramechhap Sindhupal-chowk	75	26	Doti	Doti	200
13	Helambu		50	27	Surkhet	Surkhet	145
14	Dhading	Dhading	32	28	Darchula	Darchula	50
				29	Dharan	Sunsari	112
				30	Gularia	Bardiya	100

Fig-7 Small Hydropower Projects in Nepal

PRONUNCIATION GUIDE