THE KINGDOM OF BHUTAN

MINISTRY OF AGRICULTURE AND FORESTRY

FEASIBILITY STUDY ON THE LHUNTSHI AND MONGAR INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

ANNEX

JANUARY, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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NOTATIONS

(1) Organization

Bhutan

AMC	Agricultural Mechanization Center
BGTS	Bhutan Government Transport Service
BHU	Basic Health Unit
CSO	Central Statistical Organization
DAC	Druk Air Corporation
DAH	Department of Animal Husbandry
DOA	Department of Agriculture
DOP	Department of Power
DOS	Department of Survey
FCB	Food Corporation of Bhutan
MOA	Ministry of Agriculture and Forestry
NASEPP	National Seed and Plant Program
PWD	Public Works Department
RICB	Royal Insurance Corporation of Bhutan
STC	State Trading Corporation
UTB	Unit Trust of Bhutan

International

FAO	Food and Agricultural Organization of United Nations
IBRD	The International Bank for Reconstruction and Development (World Bank)
Helvetas	Swiss Association for Development and Cooperation
IMF	International Monetary Fund
IFAD	International Fund for Agricultural Development
JICA	Japan International Cooperation Agency
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Program
UNICEF	United Nations Children's Fund

(2) Others

Dzong	Fortified monastery housing both civilian administration and monastic institution
Dzongdag	District Administrator
Dzongdag Wagma.	Deputy District Administrator
Dzongkhag	District
Dzongrab	Assistant District Administrator
EL	Elevation above mean sea level
Gup	Head of Block
Mang Gup	Head of Village
Tsheri	Shifting cultivation

ABBREVIATIONS OF MEASUREMENTS

Length

mm	=	millimeter	
cm	=	centimeter	
	=	0.39 in.	
m	=	meter	= 1.09 yd.
	=	3.28 ft.	
km	=	kilometer	= 0.62 ml.
in.	=	inch	= 2.54 cm
ft.	=	foot	= 30.48 cm
yd.	=	yard	= 91.44 cm
ml.	=	mile	= 1.61 m

Area

cm^2	=	square centimeter
m^2	=	square meter
km^2	=	square kilometer
	=	100 ha
ha	=	hectare = 0.01 km^2
	=	2.5 ac
ac	=	acre = 0.41 ha
	=	4,050 m^2
ft^2	=	square feet
	=	0.03 m^2
$mile^2$	=	square mile = 2.59 km^2

Volume

lit.	=	liter
cm^3	=	cubic centimeter
m^3	=	cubic meter
	=	1,000 lit.
MCM	=	million m^3
	=	$1x10^3$ m^3
ft^3	=	cubic feet = 0.028 m^3
	=	28.32 lit.
ac-in.	=	acre inch = 88.05 m^3
ac-ft.	=	acre feet = 1,234 m^3

Weight

g	=	gram
kg	=	kilogram
t	=	metric ton = 1,000 kg
lb	=	pound = 375 g

Time

sec	=	second
min	=	minute = 60 seconds
hr	=	hour = 60 minuits
	=	3,600 seconds
day	=	24 hrs = 1,440 minutes
	=	86,400 seconds
yr	=	year

Electrical Measures

kW	=	kilowatt = 1,000 watt
MW	=	megawatt = 1,000 KW
GW	=	gigawatt = 1,000 MW
kV	=	kilovolt = 1,000 volt

Other Measures

%	=	percent
°	=	degree
'	=	minute
"	=	second
°C	=	degree in Celsius
lakh	=	10^5

Derived Measures

m^3/sec	=	cubic meter per second (Cumec)
ft^3/sec	=	cubic foot per second (Cusec)

Monetary

US$	=	US dollar
¥	=	Japanese yen
Rp	=	Indian rupee
Nu	=	Bhutan ngultrum (1 Nu = 1 Rp)

ANNEX - I

AGRICULTURAL DEVELOPMENT IN BHUTAN

LHUNTSHI AND MONGAR
INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

ANNEX-I AGRICULTURAL DEVELOPMENT IN BHUTAN

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1. NATIONAL ECONOMY

The Kingdom of Bhutan is an agriculture oriented country with about 90% of the labour force engaged in agricultural sector. The rural economy is based on small, primarily subsistence-oriented communities.

Total estimated GDP in 1986 amounted to Nu 2,678 million or about $ 212 million at current prices as follows:

GROSS DOMESTIC PRODUCT AT CURRENT PRICE, 1986

Sector	Nu in Million	Percentage
Agriculture	1,373.8	51.3
- Agriculture	(838.5)	(31.3)
- Livestock	(271.2)	(10.1)
- Forestry	(264.1)	(9.9)
Industry	441.2	16.5
Services	863.3	32.2
Total GDP	2,678.3	100.0

Source : Central Statistical Office
Note : Details are shown in Table I.1.1.

Per capita GDP against the total population estimate of 1,312,700 is Nu 2,040 or about $ 160. This means that Bhutan is the lowest per capital income in the South Asia region and one of the lowest in the world. The agricultural sector accounted for almost half (51%) of GDP. Based on the comparison with share of agricultural labour force (90%) and agricultural GDP (51%), it is clear that productivity in agriculture is unsatisfactorily low and rural economy is kept at subsistence level.

During the 1981-1986 period, the annual growth rate of GDP was estimated at 6.3% on average and the growth rates by sector are summarized as follows:

ANNUAL GROWTH RATE OF GDP BY SECTOR

Sector	Annual Growth Rate of GDP 1981-86 (% per anum)
Agriculture	7.6
- Agriculture	(5.8)
- Livestock	(6.3)
- Forestry	(19.0)
Industry	5.4
Services	4.8
Total GDP	6.3

Source : Central Statistical Office
Note : Details are shown in Table I.1.2.

The country has close economic links with India. Trade with India in 1986/87 amounted to 99% of total exports and 84% of total imports as follows:

BALANCE OF PAYMENTS ESTIMATES, 1986/87

(Unit: Nu in million)

Item	India	Others	Total
1) Exports of Good	320.0	3.0	323.0
2) Imports of Good	(950.0)	(175.5)	(1,125.5)
3) Trade Balance (1&2)	(630.0)	(172.5)	(802.5)
4) Net Services and Transfer	(298.9)	(110.2)	(409.1)
5) Current Account Balance (3&4)	(928.9)	(282.7)	(1,211.6)
6) Foreign Aid	1,001.9	379.9	1,381.8
7) Errors & Omissions	(3.5)	18.8	15.3
8) Overall Balance (5,6 & 7)	69.6	116.0	185.6

Source : Royal Monetary Authority of Bhutan.

The trade balance deficit was accelerated, rising from a deficit of Nu 414 million in 1981/82 to Nu 803 million in 1986/87, largely due to the growth of imports. Foreign aid has contributed to offset the current account deficits and the overall balance of payments has been increasing since 1981/82.

Major export commodities to India were cement, timber and agricultural products, especially fruits, cardamon and potatoes, which accounted 73% of the total export amount in 1985 as shown in the next table. Imported goods from India were varied from consumer goods like

food, fabrics, etc. to capital goods like machinery, trucks, etc. mainly due to the promotion of national development.

5 MAJOR COMMODITIES TRADED WITH INDIA, 1985

Commodity	Nu in million	Percentage
I. Export to India		
1) Cement	55.0	20.4
2) Timber	46.8	17.3
3) Fruit products	40.6	15.0
4) Cardamon	38.0	4.1
5) Potatoes	16.1	6.0
Sub-total	196.5	72.9
Total Export	270.0	100.0
II. Import From India		
1) Diesel oil	53.4	6.7
2) Machinery parts	49.6	6.2
3) Truck chassis	41.4	5.2
4) Rice	35.5	4.4
5) Tyres and tubes	35.5	4.4
Sub total	215.4	26.9
Total Import	800.0	100.0

Source : Department of Trade and Industries.

Bhutan is an agricultural country, yet self-sufficiency of food supply has not been achieved. In terms of basic cereals, self-sufficiency is about 70%. The country has been importing cereals through the government and private channels. The cereals imported through the government channel have been increasing in recent three years and reached about 28,000 t in 1986 as follows:

IMPORTATION OF CEREALS THROUGH GOVERNMENT CHANNEL

(Unit : t)

Year	Wheat	Rice	Total
1984	4,900	12,600	17,500
1985	5,600	13,300	18,900
1986	7,800	20,300	28,100

Note: (1) Flour imported is converted to wheat at the rate of 1.67.

(2) Paddy imported is converted to rice at the rate of 0.6.

Major reasons for the increase in cereals' import are assumed to be as follows:

1) Increase in food demand for foreign construction labours for road and other public facilities, and domestic non-agricultural population such as government and private employees,

2) Increase in rice and wheat demand of rural inhabitants substituting for maize and minor cereals, and

3) Unstable production of domestic cereals, and underdeveloped inter-regional and regional marketing channels for domestic cereals.

2. NATIONAL DEVELOPMENT POLICIES FOR AGRICULTURE

2.1 Review of the 5 Year Development Plan

Bhutan has already completed five development plans since 1961. The year of 1986/87 was the last year of the Fifth Plan. The priority policies during five plans were changed according to the requirements for the development. The out lays of development plans as shown in Table II.2.1 and their principals are summarized as follows:

1) The development efforts toward transport infrastructure were given first priority during the first two plans.

2) The third plan was the first one implemented under the Planning Commission of the Royal Government. Social services on education and health were strengthened during the Third Plan.

3) The investment to the productive sectors such as agriculture, forestry and industry/mining was increased during the Fourth Plan. Agriculture and forestry received the highest priority in this plan.

4) The main objective of the Fifth Plan was to increase the country's economic self-reliance through (i) decentralization of development efforts to 18 district administration, (ii) achievement of self-sufficiency in agriculture, (iii) industrialization derived from natural resources and indigenous raw materials, (iv) promotion of education and training to meet the country's development requirement, and (v) consolidation and expansion of social services, communication and infrastructure programs.

5) The outlays on public works department during the Fifth Plan showed a significant share (about 20% included urban development to the total outlay). The expenditures for agriculture, forestry, mining and industry were also increased. The decentralization policy was initiated in Bhutan during the Fifth Plan.

Bhutan Government has constraints on trained staffs together with development funds especially in the district level, hence the development activities have not sufficiently achieved their objectives. Shortage of trained personnel should be solved through the implementation of the Sixth Plan.

2.2 The Sixth Plan

The Sixth Plan is finalized in 1987 by the Planning Commission. Main objectives of this plan are (i) to create a strong, well integrated and just society within the country, (ii) to attain national self reliance by enhancing economic, social and political capability, and (iii) to preserve and promote the rich cultural heritage and to cherish the values and institutions.

For the achievement of the above objectives, the Bhutan Government prepares the eight strategies and policies. Most of the policies in the Sixth Plan follow those of the Fifth Plan with the decentralization efforts to the Dzongkhag (District). The improvement of tax system and government efficiency, and encouragement of private sector are the new additions to the Sixth Plan.

Development objectives in the agricultural sector are (i) the achievement of self-sufficiency in staple foods, (ii) an increase in farmer's income through an increase in land and labor productivity balanced with soil and water conservation, (iii) the contribution to the GDP and export earnings. An area-based development approach is taken as the master strategy in the Sixth Plan by Ministry of Agriculture. Based on the existing geo-physical features, north to south road system and regional economic linkage, the Ministry recommends the water-shed linked area development consisting of the four regions. These regions have north-to-south roads which are Thimphu to Phuntsholing, Wangdiphodrang to Sarbhang which is under construction, Tongsa to Gaylegphug, and Tashigang to Samdrup Jongkhar. The northern and southern areas in each region have a strong economic linkage at present. Agricultural development programs during the Sixth Plan will be established taking more area-focused approach than before, in accordance with the decentralization policy. The following new development efforts will be carried out under the Sixth Plan along with all on-going activities:

1) Promotion of new integrated area development projects.

2) Promotion of rehabilitation of small scale irrigation systems.

3) Strengthening of the functions of the Center for Agricultural Research and Development (CARD) at Wangdiphodrang with the establishment of a new agricultural training center.

4) A varietal testing and farming systems research program on maize.

5) Assessment of fertilizer effect on the yield increase

6) Improvement of centralized collection system of meteorological and hydrological data.

7) Re-structuring and reviewing of the activities of the Food Corporation of Bhutan.

3. AGRICULTURAL DEVELOPMENT IN BHUTAN

3.1 Agricultural Production

Bhutan is mountainous and rugged land country. About 28,400 km^2 or 70% of the total land surveyed by remote sensing in 1983 is covered by forest. Only about 3,560 km^2 or 9% is used for agricultural purposes as shown in the following table:

Land	Area (km^2)	%
I. Area Surveyed (87%)	40,250	100
- Agricultural Land	3,560	9
- Forest Land	28,400	70
- Other Land	8,290	21
II. Area Unservey (13%)	6,250	
III. Total Land Area (100%)	46,500	

Source : Statistical Yearbook of Bhutan, 1987

Agricultural land is divided into five (5) items based on the land features and crops cultivated. Wet land is terraced and bounded and usually cultivated for paddy under irrigation but often rainfed condition. Dry land, usually sloping fields and not terraced, is permanent fields for the cultivation of dry land crops under rainfed condition. Tsheri or pangshing land is under shifting cultivation land and used for dry land crops once every five to six years. The other land categories are kitchen garden and orchard including plantation. Most of the agricultural land is in the wet and dry land categories which are about 24% and 52% of the total area respectively as shown in below:

Agricultural Land	Area ('000 ha)	%
Wet Land	29.7	23.5
Dry Land	65.8	52.0
Tsheri/Pangshing	11.9	9.4
Kitchen Garden	1.3	1.0
Orchard/Plantation	17.9	14.1
Total	126.6	100.0

Source : Statistical Yearbook of Bhutan, 1987

Note : These figures are based on the estimates of district officials and conflict with the figures by remote sensing methods.

Crop productivity is usually low as shown in the following table mainly due to traditional farming with local varieties, and less development of farm land and irrigation facilities; most of agricultural lands except wet land are not terraced or bounded and about a half of wet land is assumed as rainfed field.

Crop	Area Harvest ('000 ha)	Production ('000 t)	Yield (t/ha)
Cereals			
Paddy	30.6	65.0	2.1
Wheat/Barley	14.4	16.0	1.1
Maize	58.5	87.3	1.5
Buckwheat/Millets	20.6	16.8	0.8
Others			
Pulses	3.0	2.6	0.9
Mustard	5.0	3.5	0.7
Potato	4.2	32.6	7.8
Chilli/Vegetable	1.7	5.3	3.1
Orange	7.8	38.7	5.0
Apple	1.6	3.5	2.2
Cardamon	8.8	3.0	0.3
Total Harvested Area	156.2		

Source : Statistical Yearbook of Bhutan, 1987
Note : Data in 1984

Cropping intensity is estimated at 123% on the basis of the total agricultural lands of 1,266 km^2 and the total harvested area of 1,562 km^2.

3.2 Agricultural Development

3.2.1 Central Programs and Projects

The central programs and projects aim at nationwide promotion of agricultural support services such as research, extension, marketing and credit under the planning, execution and monitoring of the Department of Agriculture (DOA), Thimphu. During the Sixth Plan, these support services by DOA will be strengthened for the achievement of self-sufficiency in staple crops and the increase of farmers' income by introducing cash crops.

The following central programs from the previous Fifth Plan will be continued under the Sixth Plan after some arrangement for the improvement and acceleration of nationwide support services.

1) Agricultural Mechanization Program (AMP).

2) National Seed and Plant Production Program (NASEPP).

3) Input Procurement and Supply Program (IPSP).

4) Plant Protection Program (PPP).

5) Bhutan National Potato Program (BNPP).

6) Research/Extension on Rice-Based and Maize-Based Farming System.

7) Manpower Development and training.

In addition to the above programs, DOA is planning the assessment project on water and land resources as the central projects. The details on the central programs and projects above listed are summarized in Table I.3.1.

Neither the DOA nor the district offices have enough trained staff at present, hence several programs do not function satisfactorily throughout the country. Manpower development and training programs have been planned for the promotion of the other central programs.

3.2.2 Integrated Area Development Projects

Department of Agriculture will continue the integrated area development projects since the Fifth Plan on the basis of the water-shed linked area development concept, keeping in view the need for equitable development of the nation. The following development projects comprise integrated and packaged components which will improve local constraints on social and economic conditions. These projects conform to the decentralized development concept which should improve and balance capabilities in local communities:

1) Chirang Hill Irrigation Project
2) Tashigang-Mongar Area Development Project
3) Punakha-Wangdi Valley Project
4) Gaylephug Area Development Project

Besides the on-going projects above listed, Department of Agriculture has the following new projects under the Sixth Plan.

1) Lhuntshi and Mongar Integrated Agricultural Development Project

2) Paro Valley Development Project

Details of the integrated area development projects are summarized in Table I.3.2.

3.2.3 Dzongkhag (District) Schemes

Central programs and projects of the agricultural support services of the Department of Agriculture are implemented at district level as Dzongkhag Schemes and called the General Agricultural Program. Dzongkhag schemes under each district administration usually consist of the components not covered under the integrated area development projects and are coordinated with the area development projects. For the achievement of the government decentralization policy, the Dzongkhag schemes will be strongly promoted during the Sixth Plan period.

Support services under Dzongkhag schemes are provided to the farmers through the network of extension centers located at the gewog (block) level. Dzongkhag Schemes usually cover the following services:

1) Supply of improved farm inputs including tools, implements and machinery, seeds and seedlings under AMC, NASEPP and BNPP.

2) Execution of irrigation development support services including technical and economical survey, design and financial support.

3) Execution of plant protection services under PPP.

4) Extension of improved farming methods not only for basic cereals but also for promising cash crops under CARD at Wangdiphodrang and other regional research and extension centers.

5) Extension of better methods for improvement of soil fertility such as construction of compost sheds and supply of fertilizers under IPSP.

6) Execution of land development and soil conservation by terracing irrigable land, conversion of tsheri land into permanent fields, and contour bounding of dry land slopes.

The nationwide agricultural support system as shown in Fig. I.3.1 will function as the executive bodies for the achievement of self-sufficiency, an increase in farmer's income, and the promotion of decentralization to Dzongkhag and rural communities in agricultural sector.

Table I.1.1 GROSS DOMESTIC PRODUCT AT CURRENT PRICES

(Unit: Nu million)

	Sector/Activity	1981	1982	1983	1984	1985	1986
I	**AGRICULTURE**	**624.0**	**764.3**	**897.5**	**1,016.2**	**1,160.1**	**1,373.8**
	Agriculture	430.6	493.9	591.9	679.3	753.6	838.5
	Livestock	124.8	153.6	177.7	205.0	235.8	271.2
	Forestry	68.6	116.8	127.9	131.9	170.7	264.1
II	***INDUSTRY***	***222.0***	***290.7***	***338.4***	***357.5***	***351.7***	***441.2***
	Mining	4.0	6.2	4.7	6.7	10.9	14.8
	Manufacturing	48.1	52.2	69.2	79.1	94.9	96.0
	Electricity	1.1	3.0	3.1	3.2	3.6	96.0
	Construction	168.8	229.3	261.4	268.5	242.3	234.4
III	**SERVICES**	**471.5**	**534.2**	**598.4**	**677.6**	**833.1**	**906.6**
	Trade, hotels & restaurants	151.2	174.7	200.7	230.7	259.1	290.1
	Transport	32.2	36.8	44.1	50.3	60.0	68.8
	Finance, insurance & real estate	136.7	145.3	156.7	175.5	191.2	192.6
	Government services	151.4	177.4	196.9	221.1	322.8	355.1
	Less:Imputed government service charges	**(26.9)**	**(29.9)**	**(30.2)**	**(38.5)**	**(44.6)**	**(43.3)**
	TOTAL GROSS DOMESTIC PRODUCT	**1,290.6**	**1,559.3**	**1,804.1**	**2,012.8**	**2,300.3**	**2,678.3**

Source : Statistical year book in Bhutan,1987

Table I.1.2 GROSS DOMESTIC PRODUCT AT 1983 PRICE

(Unit: Nu million)

	Sector/Activity	1981	1982	1983	1984	1985	1986
I	**AGRICULTURE**	**750.7**	**836.8**	**897.5**	**929.3**	**991.3**	**1084.8**
	Agriculture	510.3	540.8	591.9	620.9	647.9	676.1
	Livestock	159.7	168.7	177.7	187.3	202.3	216.5
	Forestry	80.7	127.3	127.9	121.1	141.1	192.2
II	**INDUSTRY**	**271.5**	**321.1**	**338.4**	**325.9**	**292.6**	**353.9**
	Mining	4.2	6.5	4.7	6.3	7.7	10.4
	Manufacturing	60.5	59.6	69.2	72.5	81.0	76.3
	Electricity	2.5	2.7	3.1	3.1	3.7	91.0
	Construction	204.3	252.3	261.4	244.0	200.2	176.2
III	**SERVICES**	**546.1**	**575.9**	**598.4**	**630.0**	**665.5**	**681.7**
	Trade,hotels & restaurants	177.9	189.6	200.7	212.7	219.6	226.7
	Transport	37.9	39.9	44.1	46.3	51.4	54.8
	Finance,insurance & real estate	147.1	151.3	156.7	170	175.4	174.5
	Government services	183.2	195.1	196.9	201.0	219.1	225.7
	Less:Imputed government service charges	**(32.9)**	**(32.9)**	**(30.2)**	**(35.0)**	**(38.4)**	**(33.8)**
	TOTAL GROSS DOMESTIC PRODUCT	**1,535.4**	**1,700.9**	**1,804.1**	**1,850.2**	**1,911.0**	**2,086.6**

Source : Statistical year book in Bhutan,1987

Table I.2.1 OUTLAYS OF DEVELOPMENT PLANS FROM FIRST TO SIXTH

(Unit: %)

Sector	First Plan (actual)	Second Plan (actual)	Third Plan (actual)	Fourth Plan (actual)	Fifth Plan* (revised)	Sixth Plan
1 Agriculture	1.8	10.7	12.3	23.4	9.0	7.7
2 Food Cooperation of Bhutan	-	-	-	-	2.9	0.9
3 Animal Husbandary	1.4	2.9	5.1	5.6	3.5	3.7
4 Forestry	3.0	3.4	6.0	10.0	4.9	3.3
5 Power	1.4	4.5	6.3	4.6	7.3	12.0
6 Industry/Mines	1.0	0.5	5.3	15.8	7.0	17.1
7 Public Works Department	58.7	34.9	17.8	11.6	16.9	11.3
8 Road Transport/Aviation	7.0	5.9	2.0	-	0.6	0.6
9 Post/Telegraph	0.5	2.9	2.4	1.5	1.4	0.8
10 Telecommunication	-	-	3.1	3.4	0.7	2.8
11 Tourism	-	-	3.0	1.1	0.6	0.1
12 Education	8.8	17.7	18.9	12.2	11.2	11.1
13 Royal Institute of Management	-	-	-	-	-	0.6
14 Health	2.9	8.3	8.0	4.9	5.1	4.2
15 Information/Publicity	0.1	0.7	0.8	1.0	0.8	1.1
16 Urban Development	-	-	-	-	4.0	3.1
17 General Development	-	-	-	-	24.0	19.6
18 Others	13.4	7.7	8.9	4.9	-	-
Total - Percentage (%)	100.0	100.0	100.0	100.0	100.0	100.0
- Amount (Million Nu)	107.2	202.2	475.2	1,106.2	4,648.3	9,485.0

Note: * : The figures are revised allocations as presented in the Fifth Plan and excluded Chhukha Hydel Project.

Source : Documents produced by Planning Commission.

Table I.3.1 Central Program/Project under the Sixth Plan of DOA (1/2)

Project	Duration	Present Centre of Execution	Objective/Components	Financial and Technical Assistance	Total Project Cost
I. On Going Project					
(1) Agricultural Mechanization Center(AMP)	Since 5th Plan	Paro Bondey Farm	a) Promotion of powered and simple improved tools and implements to increase cropping intensity and labour productivity	JICA	Nu. 132.6 Million
(2) National Seed and Plant Production Program (NASEPP)	Since 5th Plan (1983)	Paro Bondey Farm	a) Production, certification, packing and distribution of improved seed and plants for the existing major crops. b) Production of vegetable and other high value seeds for export. c) Establishment of nurseries for major horticultural crops. d) Production of virus-free materials with tissue culture	JICA	Nu. 95.2 Million
(3) Input Procurement and Supply Program (IPSP)	Since 2nd Plan	Head Quarter (Thimphu)	a) Supply of fertilizers and soil nutrients at subsidized prices	_	Nu. 5.0 Million
(4) Plant Protection Program (PPP)	Since 2nd Plan	Head Quarter (Thimphu)	a) Reduction of field and storage damages lossed by pest and diseases b) Training and supply of agro-chemicals.	EEC	Nu. 30.0 Million

RGOB : Royal Government of Bhutan
JICA : Japan International Cooperation Agency
EEC : European Economic Community
CIP : International Potato Center
Helvetas : Swiss Association for Development Cooperation
IRRI : International Rice Research Center
IDRC : International Development Research Center

Table I.3.1 Central Program/Project under the Sixth Plan of DOA (2/2)

Project	Duration	Present Centre of Execution	Objective/Components	Financial and Technical Assistance	Total Project Cost
I. On Going Program					
(5) Bhutan National Potato Program (PPP)	Since 4th Plan (1980)	Head Quarter (Thimphu)	a) Increase in potato production and productivity with improved seeds. b) Training and marketing studies to get high returns.	CIP Helvetas/SDC	Nu. 27.5 Million
(6) Research/ Extension on Rice-Based and Maize-Based Farming System	Since 5th Plan (1984)	CARD (Wangdi-phodrang)	a) Research and extension of improved farming systems of rice and maize.	IRRI IDRC CIMMYT	
(7) Manpower Development and Training	Since 5th plan (1984)	Head Quarter (Thimphu)	a) Additional recruitment and replacement to expatriate staff b) Establishment of National Agriculture Training Institute and three regional sub-centers at Kanglung, Bur and Paro. c) Promotion of training for staff and farmers.	UNDP SDC	Nu 51.4 Million
II. New Project					
Assessment Project on Water and Land Resources	6th Plan	Head Quarter (Thimphu) CARD	a) Implementation of survey on soil and ground water potential. b) Preparation of land use and land resource maps (1:20,000)	RGOB	Nu. 14.8 Million

SDC : Swiss Development Community

Table I.3.2 Integrated Area Development Project under the Sixth Plan of DOA (1/2)

Project	Duration	Location (Phase)	Objective/Components	Financial and Technical Assistance	Total Project Cost
I. On Going Project					
(1) Chirang Hill Irrigation Project	1986-	(Implementing)	a) Increases in production and incomes in five watersheds in Chirang District (5,000ha) through: b) Improvement of existing irrigation infrastructure (1,310ha). c) Conservation works and water shed management (1,210ha). d) Support services on demonstration, training and seed production.	ADB Loan RGOB Loan	Nu. 43.3 Million Nu. 10.0 Million
(2) Tashigang-Mongar Area Development Project	1986-1992	Tashigang Mongar (Implementing)	a) Increase in food production and employment through: b) Improvement of irrigation schemes (200ha) and new irrigation development (350 ha). c) Provision of feeder road (34km). d) Strengthening extension services. e) Establishment of a center on a adaptive trial. f) Credits services for production and weavings.	IFAD Loan UNDP Grant RGOB Loan	Nu. 57.0 Million Nu. 9.0 Million Nu. 14.0 Million
(3) Punakha Wangdi Valley Area Project	1988-	Thimphu Punakha Wangdi-phodrang (Implementing)	a) Increase land and labour productivity through: b) Irrigation rehabilitation; area of 2,200 ha, canal length of 115 km. c) Improvement of water distribution and on-farm water management. d) Strengthening of the extension services.	IFAD Loan RGOB Loan	Nu. 45.8 Million Nu. 14.5 Million

Table I.3.2 Integrated Area Development Project under the Sixth Plan of DOA (2/2)

Project	Duration	Location (Phase)	Objective/Components	Financial and Technical Assistance	Total Project Cost
I. On Going Project					
(4) Gaylegphug Integrated Area Development Project	Since 5th Plan	Gaylegphug (Under preparation of implementation)	a) Formulation of agricultural development plan covering 11,000 ha out of Gaylegphug District through: b) Improvement of cropping pattern with integrated support services. c) Establishment of multipurpose agro-industry. d) Construction (10km) and rehabilitation (62.4km) of irrigation canal. e) Land terracing (320 ha) and soil conservation.	Indian Grant	Nu. 40.5 Milion
II New Project					
(1) Lhuntshi-Mongar Integrated Agricultural Development Project	6th Plan	Lhuntshi Mongar (Under F/S)	a) Formulation of integrated agricultural development project through the investigation of 16 schemes in the area.	JICA Grant T/A	-
(2) Paro Valley Development Project	6th Plan	Paro (Pre-F/S completed)	a) Up-grading social and economic conditions through: b) Rehabilitation of irrigation schemes and feeder roads. c) Construction of a bridge. d) Land consolidation. e) Strengthening support services. f) Promotion of powered and simple improved tools and implements to increase cropping intensity and labour productivity.	-	-

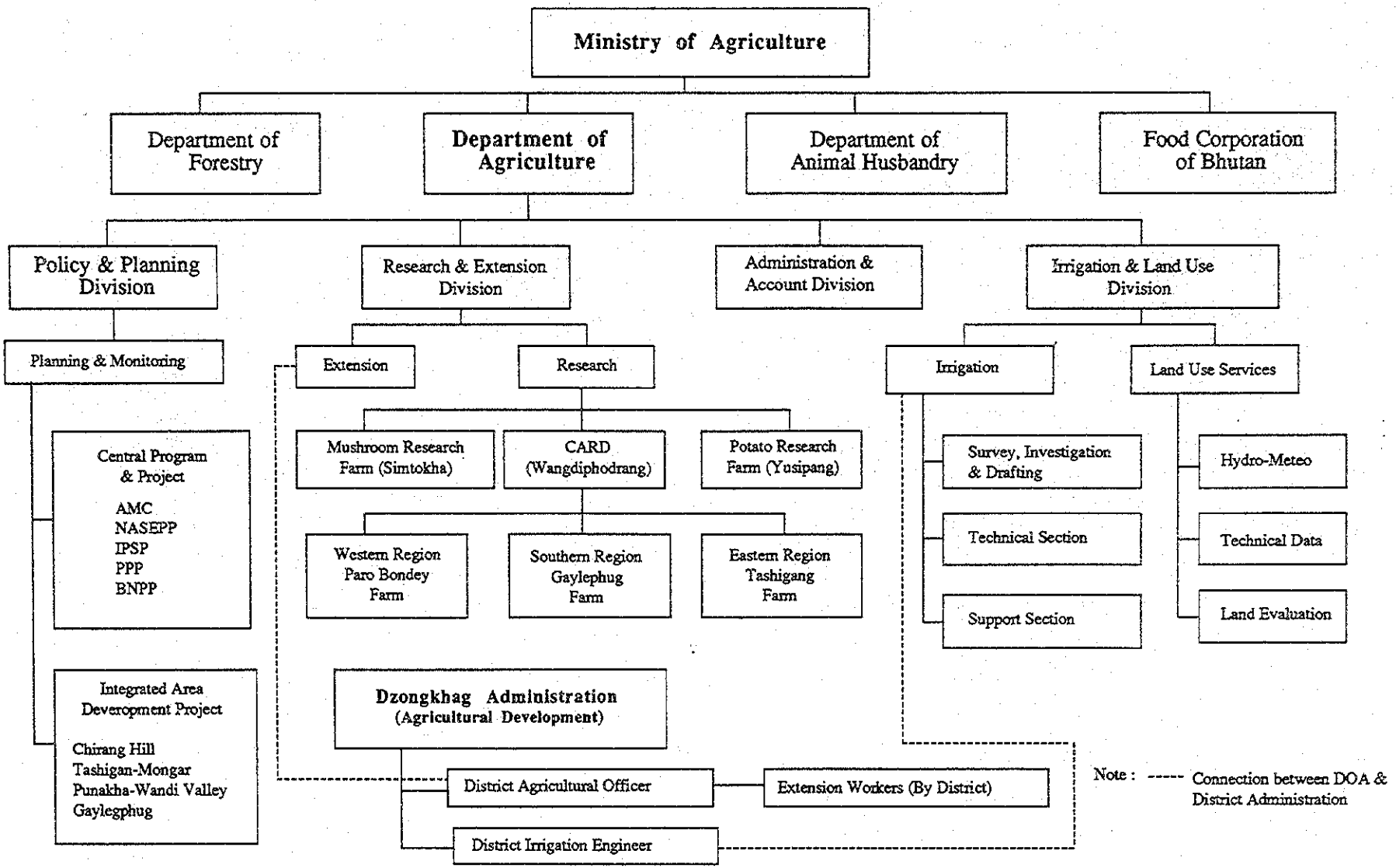

Fig. I.3.1 ORGANIZATION OF NATIONWIDE AGRICULTURAL SUPPORT SYSTEM

ANNEX - II

METEOROLOGY AND HYDROLOGY

LHUNTSHI AND MONGAR
INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

ANNEX-II METEOROLOGY AND HYDROLOGY

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1. METEOROLOGY

1.1 General

Bhutan is located in monsoon Asia and is one of the important areas for clarifying the climate of Himalayas and the mountain climatology. In a mountainous country such as Bhutan, climatic conditions weave a complex pattern. Variations in exposure to the sun and the hours of sunlight, and sharp difference in rainfall within small areas are the characteristics of climate in Bhutan.

At least, three major climatic regions in Bhutan can be recognized: the hot and humid subtropical area of the southern foot hills, the cooler (microthermal) region of the inner Himalaya and the tundra region of the great Himalaya. Although each of the basic weather elements such as temperature, pressure, precipitation and winds varies with altitude, temperature is the primary criterion for this division.

A humid subtropical climate is experienced in the country, prevailing at altitudes between 1,200 m and 1,500 m.

The inner Himalayan ranges have microthermal climates, quite difficult to clarify on a map. Winter ranges from moderately cool to severe, and summer varies from warm to cool and is rainy.

The lower zone of the microthermal Himalaya climates includes narrow valleys which skirts the rugged slopes of the inner Himalaya ranges.

In the upper part of the microthermal climate zone, above 3000 m, winter is severe and summer is short and cool. This zone may be distinguished from the lower zone in two respects. First, it is a zone of frost which does not occur frequently below 3,000 m. Second, it is characterized by primitive cultivation primarily devoted to such hardy crops as barley and potato. This zone extends to about 4,500 m that is the upper limit of agriculture and natural tree growth. The relative positions of the tree and snow lines vary with the rainfall. In drier regions, snow lines are generally higher and the tree lines lower. The zone of alpine grassland is thus widest in dry areas and narrowest in wet.

At elevation over 4,500 m, the climate is that of a true alpine tundra. Snow accumulation in most northern part of Bhutan starts from the beginning of November and reaches its maximum in January or February. Snow begins to melt in March or April, reaching highest in May or June. Drainage is mainly through four rivers, namely, Wong chu, Sankosh chu, Togsa chu and Manas river with its many tributaries in northern and central parts.

1.2 Meteorological Data

Meteorological data limit to such as air temperature, relative humidity and rainfall observed in six (6) stations in Lhuntshi and Mongar Districts. Other meteorological data, i.e., wind velocity, sunshine hours, radiation and evaporation, are not available in both the districts. In addition, some of the data collected are questionable due to the little experience of the observer and no instructions by trained staff of Department of Agriculture. The meteorological stations and the collected data items are given below, and their locations in Fig. II.1.1.

(a) Name and location of meteorological station

District	Name	Location		
		Latitude	Longitude	Altitude
Lhuntshi	Dungkhar	91°06'56"	27°49'23"	2,000 m
	Tangmachhu	91°11'53"	27°35'38"	1,700 m
Mongar	Lingmethang	91°10'40"	27°15'36"	640 m
	Chakaling	91°13'47"	27°20'51"	1,620 m
	Yadi	91°22'27"	27°16'50	1,500 m
	Kengkhar	91°19'18"	27°06'18"	1,400 m

Source : Department of Agriculture, Hydrometeorology Division

(b) Data item

- Air temperature (daily maximum and minimum)
- Relative humidity (daily at 8:00 a.m.)
- Rainfall (daily depth)

(c) Periods of collected data

- About three (3) years from April 1985 to December 1987.

1.3 Climate of the Project Area

The climate of the project area is classified as that of the lower zone of the microthermal Himalayan climates. The climate of Lhuntshi area varies from temperate to severe to some extent. The terrain towards the south are heavily forested with temperate soft woods. Mongar area is characterized with the typical climate in the lower zone of the microthermal Himalayan climates.

The long term meteorological data are not available in the project area. The monthly meteorological data of each station for about three (3) years are shown in Table II.1.1.

1.3.1 Rainfall

The project area is located in monsoon region. The climate is characterized by two distinctive seasons, wet and dry, according to the seasonal distribution of rainfall. During the period from November to March, the monthly rainfall is very little in almost all stations. The rainfall increases from April and is concentrated during June to September. An annual mean rainfall is about 830 mm and 980 mm in Lhuntshi and Mongar area respectively. The mean monthly rainfall for both areas is shown below :

Rainfall (1985 - 1987)

(unit : mm)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Lhuntshi	3.1	0.0	55.3	79.4	70.7	130.6	169.8	109.8	116.8	74.5	10.7	5.0	825.7
Mongar	1.8	30.5	43.2	83.9	73.8	169.3	200.1	133.5	168.9	52.7	9.7	10.2	977.6

Source : Department of Agriculture, Hydrometeorology Division

The rainfall data at Dungkhar and Kengkhar stations are excluded for the estimate of mean monthly rainfall, since both the stations are some far away from the project area.

1.3.2 Temperature

The mean temperature in Lhuntshi area is about 16°C over the year with the highest mean monthly maximum of 24° in June and the lowest mean monthly minimum of 5°C in January. In Mongar area, the mean temperature is about 20°C over the year, having the highest mean monthly maximum of 28°C in June and the lowest mean monthly minimum of 9°C in January.

Air Temperature (1985 - 1987)

(Unit : °C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
Lhuntshi													
Max.	13.8	15.3	17.3	20.6	21.8	23.8	22.8	23.7	22.6	21.1	18.1	14.7	19.6
Min.	5.0	7.6	10.3	12.5	14.9	18.7	19.1	19.5	18.3	15.9	9.9	6.7	13.2
Mean	9.4	11.5	13.8	16.6	18.4	21.3	21.0	21.6	20.5	18.5	14.0	10.7	16.4
Mongar													
Max.	19.6	20.9	22.7	25.2	26.7	28.2	27.2	28.1	27.0	25.6	22.8	20.4	24.4
Min.	8.8	10.0	12.3	15.6	17.5	20.9	20.9	21.0	19.8	15.3	11.6	9.4	15.2
Mean	14.2	15.5	17.5	20.4	22.1	24.5	24.0	24.6	23.4	20.5	17.2	14.9	19.8

Source : Department of Agriculture, Hydrometeorology Division

1.3.3 Relative Humidity

The monthly mean relative humidity in the morning hours varies from about 70% to 90% and the annual mean is about 78% in both Lhuntshi and Mongar areas.

Relative Humidity (1985 - 1987)

(Unit : %)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Av.
Lhuntshi													
	68.0	71.3	72.1	69.3	75.2	79.3	88.1	85.0	87.0	80.9	79.3	76.9	77.7
Mongar													
	71.4	73.7	67.3	70.6	73.7	81.7	86.6	83.2	86.5	79.6	76.2	76.8	77.3

Source : Department of Agriculture, Hydrometeorology Division

1.4 Climate of the Model Project Area

The climate of the model project area is classified as that of lower zone of the microthermal Himalayan climate. In general, it is humid and warm in wet season or summer and it is dry and cold in dry season or winter.

There are six meteorological stations in both districts. Out of the above stations, meteorological data of Tangmachhu and Lingmethang stations are adopted respectively for the model project studies because the above stations are located in the respective model project areas. Monthly meteorological records such as rainfall, temperature and relative humidity are presented in Table II.1.1 and illustrated in Fig. II.1.2.

The model project areas are located in monsoon region. This monsoon divides the climate into two pronounced seasons. The wet season generally lasts from June to September, while the dry season occurs from November to March. April, May and October are transition periods of these seasons. An annual mean rainfall is about 830 mm and 985 mm respectively in Tangmachhu and Masangdaza integrated project areas. More than 60% of annual rainfall is concentrated in the wet season.

The mean air temperature in Tangmachhu area is about 16°C over the year with the highest mean monthly maximum of 24°C in June and the lowest mean monthly minimum of 5°C in January. In Masangdaza integrated area, the mean temperature is about 23°C throughout the year, having the highest maximum of 32°C in June and the lowest minimum of 9°C in January.

An annual mean relative humidity is about 78% in both model project areas and varies from about 70% in dry season to 90% in wet season. The lowest relative humidity occurs in January and April respectively in Tangmachhu and Masangdaza integrated area and the highest appears in July and September in each area.

2. HYDROLOGY

2.1 Water Resources

The major river flowing southward through Lhuntshi and Mongar Districts is Kuri chu which has a catchment area of about 4,000 km^2 at the confluence with Manas river at the southern boundary of Mongar District. Kuri chu has its source in snow clad great Himalayan ranges. In its upper reaches, it is formed of two major rivers known as Lhubrak chu and Khoma chu (See Fig. II.2.1). Sheri chu, running southward in parallel with Kuri chu in eastern side, is a tributary of Damgme chu which joins Manas river at the confluence with Kuri chu. Shongar chu is a tributary of Kuri chu and originates from the mountainous boundary between Mongar and Bumthang Districts. It flows sotheastward along the national road and joins Kuri chu downstream of the suspension bridge (Kurizampa) in Mongar.

There are numerous small to medium sized tributaries flowing into Kuri chu, Khoma chu, Sheri chu and Shongar chu in the project area, and these tributaries are main water resources of irrigation water and power generation for the project area. The discharge of these tributaries, however, is rather small and unstable due to the small size of catchment areas and the considerable variation in local precipitation.

In addition, small mountain streams, which are scattered in the project area, are blocked by the construction of canals and the water of these streams flows into the main canal directly or through inlet structures as supplementary water resources.

The main water resources of each project area are as follows:

Project Area	Name of Tributary	Parent River
Lhuntshi District		
1. Pang Khar	Paka chu	Yongla chu and khoma chu
2. Gangzoor	Lekpagang chu	Kuri chu
3. Tangmachhu	Begang Sher and Ngeh chu	Kuri chu
4. Minji	Narigang chu	Kuri chu
5. Menjibi	Begang chu	Majebiri chu and Kuri chu
6. Kupinesa	Dungkhar chu	Rogam chu and Kuri chu
7. Wambur	Kheba chu	Kuri chu
Mongar District		
1. Chali	Thruwan chu (Diwang chu)	Kuri chu
2. Karbithang	Shongjari chu	Shongar chu and Kuri chu
3. Karibee	(Shongjari chu)	(Shongar chu and Kuri chu)
4. Masangdaza	Shongjari chu	Shongar chu and Kuri chu
5. Pangsibi	(Shongjari chu)	(Shongar chu and Kuri chu)
6. Gyelposhing	Drodi ri (Dagsamanang ri)	Kuri chu
7. Kalapang	(Kalapang and Dubrang ri)	(Yunari chu and Kuri chu)
8. Yadi	Seri chu	Sheri chu
9. Chaskhar	Goda and Loda ri	Sheri chu

Note : Tributary in parentheses is a prospective main water resource.

The runoff of rivers will fluctuate depending on the climate, topography, geology and vegetation of the catchment area. The geology of the project catchment area is characterized by being made of shallow soils developed mainly on slaty, micaceous schists rocks.

A notable feature of the vegetation in the project catchment area has great variation and the continuous gradation from subtropical to subalpine forms. Most catchment areas of the water resources lie between approximately 1,500 m to 3,000 m in altitude and are covered with fairly dense mixed jungle consisting of many species mainly pines, oaks, rhododendrons, conifers, etc. In the upper part of the temperate coniferous forest at an altitude of approximately 3,400 m to 3,700 m, the vegetation consists of fir mixed with birch. In the lower part of the alpine vegetation zone, at about 4,000 m, an abundance of low bushes and rhododendrons grow in the well-drained soils, and scaly junipers in the sunny and dry sites.

The catchment area at the existing intake sites of respective water resources is very small, ranging from a few square kilometers to about 35 km^2. Altitudes vary between about 800 m and about 4,000 m. The lengths of tributaries from intake site to upstream ridge are also very short, ranging between a few kilometers to about 10 km and the tributary slopes are therefore very steep with a mean slope of about 1:3. The characteristics of each river basin in the project areas are presented in Table II.2.1.

There are two river discharging gauging stations in Kuri chu and one station in Khoma chu. These stations are operated by Department of Power. Two discharge gauging stations were established by Tashigang and Mongar Development project, in Chali and Chaskhar intake sites. However, the above gauging sites are unsuitable for the discharge gauging due to the poor topographical and water flow conditions. No other discharge gauging stations are found, having long term discharge data for these small and medium sized tributaries.

2.2 Hydrological Data

Since no hydrological data are available in the project area for assessing the discharge of tributaries, the hydrological data of small and medium sized tributaries around the project area of which gauging stations are scattered over Bhutan, were collected from Department of Power in Ministry of Trade and Industries. Rainfall data near the above tributaries, which are observed by Department of Civil Wireless, were also collected from the Department of Agriculture.

However, no gauging was conducted in certain periods, especially in July, August and September, and no data with due time sequence were available, regarding tributary discharge and rainfall. This is due to the poor gauging facilities and difficult gauging activities in flood conditions during the rainy season.

In addition the topographic maps, with a scale of 1:50,000, showing the catchment area of the above tributaries, were obtained from Department of Survey and Land Records in Ministry of Home Affairs. The map of northern part along the boundary between Bhutan and China could not be collected due to prohibition of issuance.

The list of collected data are presented in Table II.2.2 and the locations of river discharge and rainfall gauging stations are shown in Fig. II.1.1.

The inspection of river discharge gauging stations at Sumpa, Autsho and Mongar was carried out during the field survey period. The water level of river is observed by use of some gauging staffs. The gauging staffs are in good conditions except minor defects. It is reported that the gauging staffs are often washed away by flood during rainy season. The observation of flow velocity is conducted by surface float and stop watch and therefore, some abrupt variations of discharge might be recorded in the improper flow conditions.

2.3 Water Level Gauge and Rainfall Gauge

In order to investigate the discharge of tributaries, the water measurement facilities were constructed by the Study Team, because no reliable hydrological data are available in the project area.

In the Tangmachhu project area, the concrete flume of wet masonry with 5.0 m long and 5.5 m wide was constructed upstream of the existing lower intake site in Begang chu, taking into account topographical and hydrological conditions. The automatic water level gauge was installed near by the concrete flume to measure the water depth in flume. The automatic rainfall gauge was established in the plain area at about 200 m higher than the intake site.

In the Masangdaza project area, the broad crest weir with crest length of 4.0 m and crest width of 1.5 m was built by wet masonry just down stream of Karbithang intake site, considering the topographical and hydrological conditions. The automatic water level gauge was also installed at right side of the tributary to measure the overflow water depth. The automatic rainfall gauge was installed in an open area about 50 m higher than the intake site.

The measurement of water level was started respectively in 16 February, 1988 at Tangmachhu and in 18 February, 1988 at Masangdaza. The rainfall observation was commenced on 17 March, 1988 at Tangmachhu and on 16 March, 1988 for Masangdaza.

Based on the discharge measurements at the above gauging sites carried out by current meter during the field survey periods of second phase, the rating curve for each site was developed as shown in Fig. II.2.2 and can be utilized for low range of water levels.

2.4 Assessment of Water Resources on the Project Area

2.4.1 General

In the absence of gauging stations and hydrological data on the project small and medium sized tributaries, the assessment of water availability of drought discharge was carried out on monthly basis applying monthly minimum specific discharge and annual rainfall ratio by use of discharge records of selected river around the project area which shows the similar characteristics of river basin and rainfall distribution pattern to those of the project tributaries.

2.4.2 Data Availability

The discharge data are available at 16 river discharge gauging stations in and around the project area as mentioned in Section 2.2. In the project area, there are three stations on Kuri chu at Sumpa, Autsho and Mongar, and one station on Khoma chu at Sumpa. However, these rivers originate from the perpetual snowfed area in great Himalayan ranges above an elevation of 4,600 m and include runoff of snow melt. The runoff characteristics are different between the rivers with snowfed river basin and without snowfed basin. The maps are not available to estimate the catchment area of these rivers. The

discharge data of these rivers shall not be, therefore, adaptive to assess the available water of the project tributaries which almost have no snowfed river basin. In addition, the collected discharge data of Sankosh chu at Dubani station, Mangde chu at Refe, Kholong chu at Tashiyangtshi are not appropriate for the assessment of available water due to the same reason. Nangni chu and Gongzoor chu are not applicable owing to the short-term discharge data of one or two years and Aie chu can not be utilized on account of no available maps to measure the catchment area.

The discharge data of seven other stations are available to estimate those of the project tributaries and cover only four or five years from 1982 to 1987. Rainfall data at the above stations are also available and covers the same or shorter-term than that of discharge records. Monthly discharge and rainfall records at the above seven stations are presented in Tables II.2.3 and II.2.4.

As for the project area, monthly rainfall data except DOA data are available at Mongar (Kurizampa) station operated by Department of civil Wireless from 1976 to 1987, including some data lacking period and presented in Table II.2.4

2.4.3 Selection of Applicable River

On the basis of the available discharge and rainfall data at seven stations, the characteristics of respective river basins were compared with those of the project tributaries for the purpose of selection of the most proper river which is applicable to estimate the available water of the project tributaries.

The characteristics of each river basin were studied and presented in Table II.2.5 and illustrated in Fig. II.2.3.

Monthly rainfall distribution patterns were prepared by use of available rainfall data at respective stations and Mongar (Kurizampa) rainfall station, and given in Fig. II.2.4.

As a result of the synthetic comparison with mean characteristics of all project river basins and rainfall distribution pattern, it is considered that Jiri chu, which is located nearest the project area, has the most similar basin characteristics and rainfall distribution pattern. Therefore, discharge and rainfall data of Jiri chu were applied to assess the available water of the project tributaries in this study.

2.4.4 Assessment of Water Availability

Jiri chu with catchment area of 26.3 km^2 is located in about 35 km southeast from Mongar District capital. Monthly mean and

minimum discharge records during the short period from 1981 to 1985 and monthly rainfall from 1982 to 1985 are presented respectively in Tables II.2.3 and II.2.4. However, the long-term discharge and rainfall records are not available and the probability analysis is meaningless to be conducted with such short-term data currently available. In order to assess monthly available water for the project tributaries, monthly minimum specific discharge shall be applied for the estimate of drought discharge.

In addition, the relationship between specific discharge and annual rainfall was studied by use of the available records at seven stations. As shown in Fig. II.2.5, the specific discharge is increased in direct proportion to the amounts of annual rainfall. It is therefore considered appropriate to apply this specific discharge to the project tributary discharge in the proportion of the amounts of annual rainfall.

The specific discharge to be applied to the assessment of water availability on the project tributaries are as follows:

Month	Actual Discharge (m^3/s)		Specific Discharge to be applied ($lit./s/km^2$)	
	Mean	Minimum	Mean	Drought
Jan.	0.800	0.494	16.6	10.3
Feb.	0.628	0.456	13.0	9.5
Mar.	0.680	0.419	14.1	8.7
Apr.	1.027	0.510	21.3	10.6
May	1.192	0.755	24.7	15.7
June	1.817	0.962	37.7	20.0
July	3.197	1.477	66.3	30.7
Aug.	2.405	1.132	49.9	23.5
Sep.	2.639	0.864	54.8	17.9
Oct.	1.320	0.808	27.4	16.8
Nov.	1.078	0.771	22.4	16.0
Dec.	0.876	0.617	18.2	12.8
Average	1.472	0.772	30.5	16.0

Note: - Catchment area of Jiri chu basin is 26.3 km^2.
- Annual rainfall ratio between Jiri chu area and project area is 0.55.

The above specific discharge was compared with those of various rivers with catchment area from 14 km^2 to 87 km^2 in Nepal. As presented in Table II.2.6, mean and minimum specific discharges in Nepalese rivers range from 28 to 79 $lit./s/km^2$ and from 19 to 50 $lit/s/km^2$ respectively. Therefore, the above estimated specific discharge is considered to be conservative values and reliable to be

applied to the assessment of water availability of the project tributaries.

The drought discharge on the respective project tributaries are as shown in Table II.2.7.

2.4.5 Water Quality

For the purpose of checking water qualities of the project tributaries for irrigation, the electric conductivity and pH tests were carried out. Water samples were collected at the each existing intake site on the project tributaries. The test results are presented in Table II.2.8

The values of electric conductivity ranges from 25 µmhos/cm to 120 µmhos/cm and those of pH varies from 7.25 to 8.00. It can be said that the water qualities of the project tributaries are satisfactory for irrigation water.

2.5 Water Resources on the Model Project Area

2.5.1 River System and River Basin

(1) Tangmachhu Project Area

The major water resources of this project area are Begang Sher chu and Begang Ngeh chu as shown in Fig. II.2.6. Begang Ngeh chu is the tributary of Begang Sher Chu. These rivers originate from the mountain which lies in western side at the distance of about 10 km from the project area and flow down southeastward. Begang Sher chu joins with Begang chu which is the main water resource for Menjibi project area, and flows down eastward to Kuri chu as Majebiri chu in southern side of the project area.

The catchment area at Gorgan intake is 15.1 km^2 and altitude varys between about 2,000 m and 4,000 m. The length of main river from intake site to upstream ridge is 6.7 km with an average slope of 27%. Most of catchment area are covered with heavily dense mixed jungle.

(2) Masangdaza Integrated Project Area

Shongjari chu is a major water resource for this project area as shown in Fig. II.2.6. It originates from the mountain ranges located in southern part of the project area. It flows down northeastward between Manangdaza and Karbithang project areas and joins with Shongar chu. Shongar chu is running from east to west in northern side of the project area and flows into Kuri chu.

The catchment area at Bongdima intake is 22.0 km^2 and altitude ranges from 800 m to 2,800 m. The length of the river from intake site to upstream ridge is 7.3 km with an average slope of 27%. The catchment area is covered with fairly dense mixed jungle consisting of many species mainly pines, oaks, conifers, etc.

2.5.2 Assessment of Water Availability

The water availabilities on the project tributaries were estimated on monthly basis, applying the monthly specific discharge and annual rainfall ratio by use of discharge records of the selected river, Jiri chu, which shows the most similar characteristics of its river basin and rainfall distribution pattern to those of the project tributaries as mentioned in the previous section.

The assessment of water availabilities on the model project areas, i.e., Tangmachhu and Masangdaza integrated areas, was made on 10-day basis in conformity to the above procedure.

The mean and minimum discharge records on 10-day basis during the period from 1981 to 1985 are presented in Table II.2.9 and the specific discharges to be applied for the assessment are also given in Table II.2.9.

According to the above specific discharge, the available discharges, that is, mean and drought discharges at the prospective intake sites in both model project areas are computed as shown in Table II.2.10.

During the field survey periods, the discharge measurement of the tributaries in the model project areas were carried out by current meter and the measurement results are given in Table II.2.11.

The comparison of the estimated mean discharges in March, July and August with the discharges measured by the Study Team shows the proper assessment of water availabilities of project tributaries.

2.5.3 Flood Discharge

(1) General

In order to analize the flood pattern, the hourly water level data as well as the hourly rainfall data by an automatic gauges are essential in general. The automatic gauges were established on the major rivers in Tangmachhu and Masangdaza areas in the first phase of the Study. Unfortunately, it is very difficult to analize the correlation of recorded rainfall and flood because there was no opportunity to observe the flood discharge in the study period and in addition have been no flood data on the project tributaries.

Therefore, in this study, the flood discharge on the project tributaries were estimated by Rational Formula which is recommended in the Hydrology Manual published by Department of Agriculture that it is applicable and suitable for the catchments with area less then 25 km^2.

(2) Estimate of Flood Discharge

The peak flood discharge of rivers on the model project areas were assessed by use of the Rational Formula as shown below:

$$Qp = 1/3.6 \times C \times I \times A$$

where, Qp : Peak flood discharge (m^3/s)
C : Peak runoff coefficient
I : Rainfall intensity for the duration equal to the flood concentration time (mm/hr)
A : Catchment area (km^2)

The procedure of calculation is described hereinafter :

i) Flood concentration time

The flood concentration time is given by the summation of the time required for flood to flow out into the river course from the most remote point in the catchment area and the time required for flood to flow down through the river course up to the point to be considered. Several empirical formulas have been proposed for the estimate of flood concentration time. The time calculated by some empirical formulas are shown in Table II.2.12, and each formula presented slightly different results for the catchment. Among these formulas, the Bransby-Williams formula was adopted in this study because it is recommended by DOA and the calculated result indicates the close values to the actual time observed by automatic gauges as shown in Fig. II.2.7.

ii) Rainfall intensity

The rainfall intensity occurring over the period of time equivalent to the flood concentration time was obtained from the rainfall intensity curve for Tashigang as shown in Fig. II.2.8 which is derived from the Hydrology Manual of DOA. The values of rainfall intensity of each return period for each catchment area are given in Table II.2.12.

iii) Peak runoff coefficient

The catchment areas of the model project tributaries are covered with heavily dense mixed jungle consisting of many species mainly pines, oaks, conifers, etc. The values were obtained from the runoff coefficient curve as shown in Fig. II.2.9 which is decided in the Hydrology Manual. The estimated peak runoff coefficients for each catchment area are presented in Table II.2.12.

iv) Peak flood discharge

The peak flood discharger from the catchment area at the prospective intake site are then estimated by inputting the above calculated parameters into the Rational Formula. The results of estimate are summarized as follows:

Project Area	Name of Intake	Catchment Area (km^2)	Flood Discharge (m^3/s) Return Period in Years				
			2	5	10	25	50
Tangmachhu	Tangmachhu No. 1	5.4	8.9	11.5	12.9	15.2	16.7
	Tangmachhu No. 2	4.5	5.8	7.4	8.4	9.8	10.8
	Gorgan	15.1	17.7	23.0	25.9	30.4	33.0
Masangdaza	Masangdaza	15.2	17.8	23.0	25.9	30.6	33.2
	Bongdima/Karbithang	22.0	24.2	31.3	35.8	41.4	45.5

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (1/6)

STATION NAME : DUNGKHAR, DISTRICT : LHUNTSHI,
LAT.: 91°06'56"E, LONG.: 27°49'23"N, ALT.: 2,000m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	-	-	18.8	19.7	28.8	22.9	22.4	25.2	22.5	20.6	16.2	14.4	21.2
	Min.	-	-	9.6	11.9	12.7	16.9	17.1	17.2	16.0	12.9	7.4	4.7	12.6
	Mean	-	-	14.2	15.8	20.8	19.9	19.8	21.2	19.3	16.8	11.8	9.6	16.9
1986	Max.	13.8	14.3	19.4	22.4	22.9	22.3	23.9	23.3	21.6	19.2	16.5	13.6	19.4
	Min.	3.5	5.7	7.2	10.1	10.9	12.5	16.9	17.1	16.6	10.4	8.3	4.5	10.3
	Mean	8.7	10.0	13.3	16.3	16.9	17.4	20.4	20.2	19.1	14.8	12.4	9.1	14.9
1987	Max.	14.0	14.3	19.4	22.5	22.8	22.8	23.5	22.8	22.8	19.7	18.9	15.5	19.9
	Min.	3.5	5.1	7.0	9.3	10.7	14.4	16.4	16.7	15.5	11.7	7.2	1.3	9.9
	Mean	8.8	9.7	13.2	15.9	16.8	18.6	20.0	19.8	19.2	15.7	13.1	8.4	14.9
Average	Max.	13.9	14.3	19.2	21.5	24.8	22.7	23.3	23.8	22.3	19.8	17.2	14.5	19.8
	Min.	3.5	5.4	7.9	10.4	11.4	14.6	16.8	17.0	16.0	11.7	7.6	3.5	10.5
	Mean	8.7	9.9	13.6	16.0	18.1	18.6	20.0	20.4	19.2	15.8	12.4	9.0	15.1

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	-	-	69.0	79.1	82.4	80.6	88.8	82.9	88.9	78.0	68.5	68.6	78.7
1986	66.5	73.7	69.2	88.9	88.0	90.8	89.1	92.6	94.2	84.6	79.8	61.8	81.6
1987	64.5	73.6	72.3	88.4	88.9	83.3	85.5	84.2	70.2	81.0	84.8	73.5	79.2
Average	65.5	73.7	70.2	85.5	86.4	84.9	87.8	86.6	84.4	81.2	77.7	68.0	79.3

(3) Rainfall (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	109.8	156.2	72.0	468.7	160.5	217.8	95.9	50.0	21.6	1352.5
1986	0.0	24.2	46.0	190.0	178.6	266.9	349.9	229.2	197.2	113.8	36.0	2.0	1633.8
1987	0.0	2.0	83.4	61.0	76.4	62.9	253.3	308.2	249.2	56.5	2.6	0.0	1155.5
Average	0.0	13.1	64.7	120.3	137.1	133.9	357.3	232.6	249.4	88.7	29.5	7.9	1434.5

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (2/6)

STATION NAME : TANGMACHHU, DISTRICT : LHUNTSHI,
LAT.: 91°11'53"E, LONG,: 27°35'38"N, ALT,: 1,700m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	-	-	-	21.2	21.3	22.7	20.4	22.2	22.1	22.6	18.9	14.2	20.6
	Min.	-	-	-	13.4	15.4	19.4	18.5	20.1	19.0	16.6	10.1	6.8	15.5
	Mean	-	-	-	17.3	18.4	21.1	19.5	21.2	20.6	19.6	14.5	10.5	18.1
1986	Max.	13.6	14.5	17.8	20.6	21.8	24.0	23.8	25.2	22.9	19.8	17.0	13.8	19.6
	Min.	5.6	7.5	9.7	11.3	13.1	17.2	19.0	18.8	18.0	14.2	9.5	5.6	12.5
	Mean	9.6	11.0	13.8	16.0	17.5	20.6	21.4	22.0	20.5	17.0	13.3	9.7	16.0
1987	Max.	13.9	16.0	16.7	19.9	22.2	24.8	24.2	23.6	22.9	20.9	18.4	16.1	20.0
	Min.	4.3	7.7	10.8	12.7	16.2	19.5	19.9	19.6	17.9	17.0	10.1	7.7	13.6
	Mean	9.1	11.9	13.8	16.3	19.2	22.2	22.1	21.6	20.4	19.0	14.3	11.9	16.8
Average	Max.	13.8	15.3	17.3	20.6	21.8	23.8	22.8	23.7	22.6	21.1	18.1	14.7	19.6
	Min.	5.0	7.6	10.3	12.5	14.9	18.7	19.1	19.5	18.3	15.9	9.9	6.7	13.2
	Mean	9.4	11.4	13.8	16.5	18.3	21.3	21.0	21.6	20.5	18.5	14.0	10.7	16.4

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	70.7	80.4	81.4	89.8	81.5	81.8	81.3	73.6	74.0	79.4
1986	69.5	73.7	64.5	65.8	69.3	74.3	86.3	84.1	88.4	74.8	77.9	70.5	74.9
1987	66.4	68.9	79.6	71.3	75.8	82.1	88.3	89.5	90.7	86.6	86.4	86.3	81.0
Average	68.0	71.3	72.1	69.3	75.2	79.3	88.1	85.0	87.0	80.9	79.3	76.9	77.7

(3) Rainfall (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	102.0	59.0	35.8	152.4	63.1	63.4	94.4	22.4	12.4	604.9
1986	0.0	0.0	10.8	59.6	88.0	194.8	206.4	103.8	111.9	87.6	9.8	2.2	874.9
1987	6.2	0.0	99.7	76.6	65.0	161.2	150.7	162.5	175.0	41.6	0.0	0.4	938.9
Average	3.1	0.0	55.3	79.4	70.7	130.6	169.8	109.8	116.8	74.5	10.7	5.0	825.7

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (3/6)

STATION NAME : LINGMETHANG, DISTRICT : MONGAR,
LAT.: 91°10'40"E, LONG,: 27°15'36"N, ALT,: 640m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	-	-	-	30.7	30.3	31.8	29.8	32.4	31.0	29.8	25.3	23.0	29.3
	Min.	-	-	-	20.5	21.0	23.2	23.4	23.9	22.3	18.7	13.6	11.5	19.8
	Mean	-	-	-	25.6	25.7	27.5	26.6	28.2	26.7	24.3	19.5	17.3	24.6
1986	Max.	22.8	25.5	27.2	28.4	31.1	31.2	31.1	32.0	29.4	28.2	26.3	23.0	28.0
	Min.	9.7	11.6	13.6	17.7	19.5	25.4	25.2	25.4	22.1	16.7	14.1	10.1	17.6
	Mean	16.3	18.6	20.4	23.1	25.3	28.3	28.2	28.7	25.8	22.5	20.2	16.6	22.8
1987	Max.	23.6	25.1	25.7	28.6	30.8	33.1	32.5	30.4	31.0	28.9	27.1	25.0	28.5
	Min.	8.2	11.6	14.9	16.7	20.8	24.0	23.6	23.1	23.0	16.6	13.7	10.3	17.2
	Mean	15.9	18.4	20.3	22.7	25.8	28.6	28.1	26.8	27.0	22.8	20.4	17.7	22.8
Average	Max.	23.2	25.3	26.5	29.2	30.7	32.0	31.1	31.6	30.5	29.0	26.2	23.7	28.3
	Min.	9.0	11.6	14.3	18.3	20.4	24.2	24.1	24.1	22.5	17.3	13.8	10.6	17.5
	Mean	16.1	18.5	20.4	23.8	25.6	28.1	27.6	27.9	26.5	23.2	20.0	17.2	22.9

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	66.2	75.8	78.1	86.2	75.5	85.4	77.6	81.4	85.6	79.1
1986	75.6	74.8	66.6	73.0	67.6	78.9	82.2	80.4	83.9	80.5	77.6	79.4	76.7
1987	76.5	75.1	77.8	74.0	74.9	90.0	84.3	86.3	86.9	80.1	77.6	79.2	80.2
Average	76.1	75.0	72.2	71.1	72.8	82.3	84.2	80.7	85.4	79.4	78.9	81.4	78.3

(3) Rainfall (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	97.8	97.0	276.0	105.8	199.8	77.6	13.2	23.6	890.8
1986	0.0	8.2	16.0	124.8	30.8	240.4	176.6	99.0	107.1	71.4	3.0	1.8	879.1
1987	1.0	18.2	83.3	78.8	63.4	223.6	95.4	151.4	255.0	43.0	1.8	4.2	1019.1
Average	0.5	13.2	49.7	101.8	64.0	187.0	182.7	118.7	187.3	64.0	6.0	9.9	984.7

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (4/6)

STATION NAME : CHAKALING, DISTRICT : MONGAR
LAT.: 91°13'47"E, LONG,: 27°20'51"N, ALT,: 1,620m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	-	-	-	24.2	24.5	25.4	24.2	27.3	25.7	25.8	21.5	19.2	24.2
	Min.	-	-	-	14.9	16.0	18.5	18.4	19.5	18.3	15.2	10.6	9.1	15.6
	Mean	-	-	-	19.6	20.3	22.0	21.3	23.4	22.0	20.5	16.1	14.2	19.9
1986	Max.	18.0	19.1	22.3	22.0	25.0	26.2	25.8	27.1	25.6	23.5	21.7	20.5	23.1
	Min.	7.4	8.6	11.1	13.3	15.3	18.7	18.8	18.8	17.8	13.3	11.5	8.3	13.6
	Mean	12.7	13.9	16.7	17.7	20.2	22.5	22.3	23.0	21.7	18.4	16.6	14.4	18.3
1987	Max.	19.7	21.2	20.7	23.6	25.4	27.2	26.0	25.3	25.9	24.7	23.4	20.7	23.7
	Min.	7.3	9.2	10.7	13.5	15.9	18.8	18.9	18.6	18.3	14.7	11.6	9.1	13.9
	Mean	13.5	15.2	15.7	18.6	20.7	23.0	22.5	22.0	22.1	19.7	17.5	14.9	18.8
Average	Max.	18.9	20.2	21.5	23.3	25.0	26.3	25.3	26.6	25.7	24.7	22.2	20.1	23.3
	Min.	7.4	8.9	10.9	13.9	15.7	18.7	18.7	19.0	18.1	14.4	11.2	8.8	13.8
	Mean	13.1	14.5	16.2	18.6	20.4	22.5	22.0	22.8	21.9	19.5	16.7	14.5	18.6

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
1986	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
1987	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
Average	-	-	-	-	-	-	-	-	-	-	-	-	-

(3) Rainfall (Unit : mm)

Yaer	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	113.3	90.0	228.8	123.2	198.6	41.8	25.0	29.0	849.7
1986	0.0	125.0	13.3	49.8	80.4	280.6	208.6	88.2	119.7	64.8	22.2	7.0	1059.6
1987	10.0	19.6	68.4	94.4	70.1	200.7	196.5	257.3	234.0	44.0	0.0	0.0	1195.0
Average	5.0	72.3	40.9	72.1	87.9	190.4	211.3	156.2	184.1	50.2	15.7	12.0	1098.2

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (5/6)

STATION NAME : YADI, DISTRICT : MONGAR,
LAT.: 91°22'27"E, LONG,: 27°16'50"N, ALT,: 1500m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	-	-	-	25.0	23.9	26.1	24.6	27.3	25.2	23.8	19.2	16.8	23.5
	Min.	-	-	-	15.7	16.4	19.2	19.2	20.3	18.5	15.0	9.2	11.6	16.1
	Mean	-	-	-	20.4	20.2	22.7	21.9	23.8	21.9	19.4	14.2	14.2	19.8
1986	Max.	16.0	17.3	20.2	21.2	24.6	25.3	24.9	26.5	24.4	23.2	19.8	16.2	21.6
	Min.	13.8	9.9	10.1	14.4	16.3	20.9	20.4	19.7	19.1	13.3	10.1	7.0	14.6
	Mean	14.9	13.6	15.2	17.8	20.5	23.1	22.7	23.1	21.8	18.3	15.0	11.6	18.1
1987	Max.	17.2	17.3	20.0	22.9	25.0	27.1	25.8	24.9	25.1	22.6	21.0	18.8	22.3
	Min.	6.2	9.1	13.4	13.3	16.7	19.7	19.8	19.4	19.2	14.7	10.4	7.5	14.1
	Mean	11.7	13.2	16.7	18.1	20.9	23.4	22.8	22.2	22.2	18.7	15.7	13.2	18.2
Average	Max.	16.6	17.3	20.1	23.0	24.5	26.2	25.1	26.2	24.9	23.2	20.0	17.3	22.0
	Min.	10.0	9.5	11.8	14.5	16.5	19.9	19.8	19.8	18.9	14.3	9.9	8.7	14.5
	Mean	13.3	13.4	15.9	18.8	20.5	23.1	22.5	23.0	21.9	18.8	15.0	13.0	18.2

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	69.1	80.5	80.8	87.3	77.7	84.1	72.2	71.0	68.0	76.7
1986	65.0	64.1	57.7	74.3	70.9	81.5	87.4	89.6	88.9	80.4	71.2	75.2	75.5
1987	68.4	76.3	66.8	66.7	72.1	80.8	92.2	89.7	89.9	86.6	68.1	73.5	77.6
Average	66.7	70.2	62.3	70.0	74.5	81.0	89.0	85.7	87.6	79.7	70.1	72.2	75.8

(3) Rainfall (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	111.8	133.2	295.9	63.9	99.7	14.5	22.5	20.4	761.9
1986	0.0	9.8	49.2	94.6	42.2	157.2	181.8	94.7	151.3	75.0	0.0	2.6	858.4
1987	0.0	2.0	29.0	61.2	54.2	101.1	142.2	218.0	154.8	42.0	0.0	2.8	807.3
Average	0.0	5.9	39.1	77.9	69.4	130.5	206.6	125.5	135.3	43.8	7.5	8.6	850.2

Table II.1.1 MONTHLY METEOROLOGICAL RECORD (6/6)

STATION NAME : KENGKHAR, DISTRICT : MONGAR,
LAT.: 91°19'18"E, LONG,: 27°06'18"N, ALT,: 1,400m

(1) Air Temperature (Unit : °C)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	Max.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Min.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	Max.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Min.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-
1987	Max.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Min.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	Max.	-	-	-	-	-	-	-	-	-	-	-	-	-
	Min.	-	-	-	-	-	-	-	-	-	-	-	-	-
	Mean	-	-	-	-	-	-	-	-	-	-	-	-	-

(2) Relative Humidity (Unit : %)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	76.1	82.5	88.8	90.0	88.2	89.5	87.3	86.0	78.5	85.2
1986	71.4	78.5	69.8	88.0	82.2	85.5	89.1	89.3	87.6	80.6	86.8	78.6	82.3
1987	66.2	63.0	78.9	76.9	84.8	90.3	87.2	87.2	90.2	84.7	89.3	85.5	82.0
Average	68.8	70.8	74.4	80.3	83.2	88.2	88.8	88.2	89.1	84.2	87.4	80.9	82.0

(3) Rainfall (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	160.0	259.9	615.0	101.6	317.0	4.0	0.0	13.1	1470.6
1986	11.8	20.5	37.0	157.9	69.7	258.5	314.1	182.9	142.1	60.9	15.3	4.0	1274.7
1987	0.0	16.3	35.1	37.3	33.0	337.5	415.2	323.8	218.4	47.4	0.0	0.0	1464.0
Average	5.9	18.4	36.1	97.6	87.6	285.3	448.1	202.8	225.8	37.4	5.1	5.7	1455.8

Table II.2.1 CHARACTERISTICS OF RIVER BASIN IN THE PROJECT AREA

No.	Site Name		Rivre Name	Intake El. (m)	Ridge El. (m)	Mean El. (m)	River Length (km)	Mean Slope of River	Catchment Area at Intake(sq.km)	Mean Width of Basin(km)
	LHUNTSHI									
1	Pang Khar		Paka Chu	2,190	2,600	2,395	0.95	0.43	0.25	0.26
2	Gangzoor		Lekpagang Chu	1,560	3,150	2,355	4.45	0.36	8.60	1.93
3	Tangmachhu	L	Begang Sher Chu	1,960	3,800	2,880	6.70	0.27	15.10	2.25
		M	Begang Nge Chu	2,210	3,800	3,005	5.10	0.31	4.50	0.88
		U	Begang Sher Chu	2,240	3,600	2,920	3.05	0.45	5.40	1.77
4	Minji	L	Narigang Chu	1,700	4,040	2,870	9.60	0.24	36.20	3.77
		U	Narigang Chu	2,190	4,040	3,115	5.45	0.34	15.38	2.82
5	Menjibi		Begang Chu	1,920	3,200	2,560	4.65	0.28	13.28	2.86
6	Kupinesa		Dungkhar Chu	2,100	3,500	2,800	3.50	0.40	6.80	1.94
7	Wambur		Kheba Chu	2,300	3,800	3,050	4.55	0.33	9.93	2.18
	Average			1,923	3,582	2,753	5.58	0.31	14.99	2.49
	MONGAR									
1	Chali		Thruwan Chu	1,670	2,800	2,235	2.50	0.45	3.53	1.41
2	Karbithang		Shongjari Chu	820	2,800	1,810	7.15	0.28	21.90	3.06
3	Karibee		Shongjari Chu	-	-	-	-	-	-	-
4	Masangdaza	L	Shongjari Chu	800	2,800	1,800	7.30	0.27	22.00	3.01
		U	Shongjari Chu	920	2,800	1,860	6.25	0.31	15.20	2.53
5	Pangsibi		-	-	-	-	-	-	-	-
6	Gyelposhing		Drodi Ri	730	2,500	1,615	6.55	0.27	13.88	2.12
7	Kalapang	L	Kalapang Chu	1,150	2,100	1,625	1.95	0.49	1.73	0.89
		U	Dubrang Chu	1,200	2,100	1,650	2.00	0.45	2.30	1.15
8	Yadi		Seri Chu	1,580	2,350	1,965	1.65	0.47	2.03	1.23
9	Chaskhar	L	Goda Ri	1,960	2,600	2,280	1.30	0.49	2.03	1.56
		U	Loda Ri	1,980	2,900	2,440	2.45	0.38	1.70	0.69
	Average			1,323	2,525	1,924	3.55	0.40	7.63	1.75

Note; L : Lower intake site M : Middle intake site U : Upper intake site

Table II.2.2 LIST OF COLLECTED DATA (1/2)
(DISCHARGE AND RAINFALL)

No.	Station Name	River Name	Dis./Rain	1980												1981											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Dubani	Sankosh Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Tansebi	Nangni Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Tansebi	Chendebji Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Refe	Mangde Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Sumpa	Khoma Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Autsho	Kuri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Mongar	Kuri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	T/Yangtshi	Kholong Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Gayleghung	Aie Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	P/Gatshel	Uri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Nanglam	Kirang Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Bangtar	Baranadi Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	T/Yangtshi	Birram Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Gangzoor	Gangzoor Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Chumey	Khangang Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Khaling	JIri Chu	D	-	+	*	+	*	*	*	*	*	*	*	*	-	-	-	+	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	River Name	Dis./Rain	1982												1983											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Dubani	Sankosh Chu	D	-	-	+	*	*	+	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tansebi	Nangni Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Tansebi	Chendebji Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Refe	Mangde Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Sumpa	Khoma Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Autsho	Kuri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	Mongar	Kuri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	T/Yangtshi	Kholong Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Gayleghung	Aie Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	P/Gatshel	Uri Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Nanglam	Kirang Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
12	Bangtar	Baranadi Chu	D	-	-	-	+	-	-	-	-	-	-	-	-	*	*	*	+	-	-	-	-	-	-	-	-
			R	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	T/Yangtshi	Birram Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	*	+	+	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Gangzoor	Gangzoor Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Chumey	Khangang Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Khaling	JIri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	River Name	Dis./Rain	1984												1985											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Dubani	Sankosh Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tansebi	Nangni Chu	D	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Tansebi	Chendebji Chu	D	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Refe	Mangde Chu	D	*	*	*	*	+	*	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	Sumpa	Khoma Chu	D	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	Autsho	Kuri Chu	D	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
7	Mongar	Kuri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	T/Yangtshi	Kholong Chu	D	*	-	*	*	*	-	*	+	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Gayleghung	Aie Chu	D	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	-	+	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*
10	P/Gatshel	Uri Chu	D	*	*	*	*	*	*	+	+	*	+	+	*	*	*	+	*	*	*	+	+	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Nanglam	Kirang Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
12	Bangtar	Baranadi Chu	D	-	-	-	-	*	*	+	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	T/Yangtshi	Birram Chu	D	*	*	*	*	*	*	*	+	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Gangzoor	Gangzoor Chu	D	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
15	Chumey	Khangang Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Khaling	JIri Chu	D	*	*	*	*	*	*	*	*	+	*	*	*	*	*	*	*	+	*	*	*	*	*	*	-
			R	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	River Name	Dis./Rain	1986												1987											
				1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Dubani	Sankosh Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tansebi	Nangni Chu	D	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Tansebi	Chendebji Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Refe	Mangde Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	Sumpa	Khoma Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	+	+	*	*	*	*	*	*	*	*	*	*	*
6	Autsho	Kuri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*
7	Mongar	Kuri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	T/Yangtshi	Kholong Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*
9	Gayleghung	Aie Chu	D	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	P/Gatshel	Uri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Nanglam	Kirang Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-
12	Bangtar	Baranadi Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-
13	T/Yangtshi	Birram Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Gangzoor	Gangzoor Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-
15	Chumey	Khangang Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	Khaling	JIri Chu	D	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
			R	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	-

Note ; * : Full daily discharge record, + : Partial daily record, - : NO daily record obtained from Department of Power

Table II.2.2 LIST OF COLLECTED DATA (2/2)
(RAINFALL)

No.	Station Name	1976												1977											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tashigang	-	-	-	*	*	*	*	*	*	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
3	Shemgang	*	*	*	*	*	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
4	Gaylegphug	*	*	*	*	*	-	*	-	-	-	-	-	*	*	*	*	*	*	*	*	-	-	-	-
5	Wangdiphodrang	*	-	*	*	*	*	*	*	*	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
6	Daga Zong	*	*	-	*	*	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	-	-	-	-
7	Kanglung	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Rangthangwoong	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Tongsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Kuengarabten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Surey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Dechhenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Dungmain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Thrimshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Ura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	1978												1979											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tashigang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	Shemgang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Gaylegphug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Wangdiphodrang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	Daga Zong	-	-	-	-	-	-	-	-	-	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-
7	Kanglung	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Rangthangwoong	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Tongsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Kuengarabten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Surey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Dechhenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Dungmain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Thrimshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Ura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	1980												1981											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tashigang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	Shemgang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Gaylegphug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Wangdiphodrang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	Daga Zong	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	Kanglung	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Rangthangwoong	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Tongsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Kuengarabten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Surey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Dechhenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Dungmain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Thrimshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Ura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	1982												1983											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	*	*	*	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	Tashigang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3	Shemgang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Gaylegphug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Wangdiphodrang	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-	*	*	*	*
6	Daga Zong	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-
7	Kanglung	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	Rangthangwoong	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	Tongsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	Kuengarabten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Surey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	Dechhenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13	Dungmain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Thrimshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15	Ura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

No.	Station Name	1984												1985											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*
2	Tashigang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
3	Shemgang	*	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
4	Gaylegphug	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	Wangdiphodrang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
6	Daga Zong	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	-	-	-	-	-	-	-	-
7	Kanglung	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	-	*	-	*	*	*
8	Rangthangwoong	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
9	Tongsa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
10	Kuengarabten	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
11	Surey	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
12	Dechhenling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	*	*	*	*	*	-	*	*
13	Dungmain	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	Thrimshing	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*
15	Ura	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*

No.	Station Name	1986												1987											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Mongar	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2	Tashigang	-	-	-	-	-	-	-	-	-	-	-	-	*	*	*	*	*	*	*	*	*	*	*	*
3	Shemgang	-	*	-	*	-	*	*	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
4	Gaylegphug	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
5	Wangdiphodrang	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
6	Daga Zong	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
7	Kanglung	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
8	Rangthangwoong	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
9	Tongsa	*	*	*	*	*	*	*	*	-	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*
10	Kuengarabten	*	*	*	*	*	*	*	*	*	*	*	*	-	-	*	*	*	*	*	-	-	-	-	-
11	Surey	*	*	*	*	*	*	*	*	*	*	*	-	*	*	*	*	*	*	*	*	*	*	*	*
12	Dechhenling	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
13	Dungmain	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
14	Thrimshing	*	*	*	-	*	*	*	-	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
15	Ura	*	*	*	*	*	*	*	*	*	*	-	*	*	*	*	*	*	*	*	*	*	*	*	*

Table II.2.3 MONTHLY MEAN DISCHARGE RECORDS (1/2)

Station Name : Tashiyangtshi
River Name : Birzam chu
Catchment Area : 12.85 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	-	-	-	-	0.521	0.718	1.003	1.300	1.177	0.828	0.685	0.594	0.853
1983	0.445	0.412	0.442	0.514	0.806	0.556	0.881	1.184	1.394	0.947	0.644	0.515	0.728
1984	0.435	0.426	0.439	0.487	0.701	0.770	1.034	0.971	1.291	0.826	0.623	0.527	0.711
1985	0.431	0.429	0.275	0.615	0.569	0.594	1.203	1.280	1.450	0.901	0.636	0.505	0.741
1986	0.433	0.426	0.405	0.496	0.633	0.689	1.338	1.094	1.033	0.988	0.761	-	0.754
Average	0.436	0.423	0.390	0.528	0.646	0.665	1.092	1.166	1.269	0.898	0.670	0.535	0.727
Minimum	0.431	0.412	0.275	0.487	0.521	0.556	0.881	0.971	1.033	0.826	0.623	0.505	0.627

Station Name : Khaling
River Name : Jiri chu
Catchment Area : 26.3 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1981	-	-	-	1.699	1.765	2.571	6.269	4.135	3.057	1.763	1.515	1.304	2.675
1982	1.314	0.830	0.751	1.027	0.963	1.432	1.477	1.132	0.864	0.808	0.807	0.800	1.017
1983	0.739	0.700	0.738	0.771	0.997	0.962	2.193	1.716	3.131	1.247	0.771	0.617	1.214
1984	0.494	0.456	0.419	0.510	0.755	2.356	2.905	2.503	3.589	1.307	1.030	0.783	1.426
1985	0.653	0.525	0.812	1.128	1.478	1.765	3.142	2.541	2.552	1.476	1.268	-	1.576
Average	0.800	0.628	0.680	1.027	1.192	1.817	3.197	2.405	2.639	1.320	1.078	0.876	1.471
Minimum	0.494	0.456	0.419	0.510	0.755	0.962	1.477	1.132	0.864	0.808	0.771	0.617	0.771

Station Name : Tansebi
River Name : Chendebji chu
Catchment Area : 429.3 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1984	-	-	-	-	-	-	-	-	-	24.626	19.304	14.490	19.473
1985	12.231	12.207	12.809	14.314	22.239	36.897	57.636	55.945	56.862	30.127	21.238	15.877	29.032
1986	10.731	9.428	8.761	9.769	13.688	27.757	39.507	35.386	36.456	29.898	18.473	13.056	21.076
1987	10.334	9.546	9.685	10.569	12.938	25.988	45.587	32.946	41.465	25.069	14.149	18.046	21.110
Average	11.099	10.394	10.418	11.551	16.288	30.214	46.577	41.426	44.928	27.430	18.291	15.367	23.665
Minimum	10.334	9.428	8.761	9.769	12.938	25.988	39.507	32.946	36.456	24.626	14.149	13.056	19.830

Station Name : Pemagatshel
River Name : Uri chu
Catchment Area : 80.95 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	-	-	-	0.917	0.914	1.803	7.037	3.180	2.619	1.790	1.162	0.867	2.254
1983	0.430	0.394	0.360	0.328	0.503	0.652	1.792	2.098	2.728	3.019	1.611	1.234	1.262
1984	1.185	1.080	0.878	0.415	0.891	1.752	2.757	13.739	5.437	4.425	2.275	1.003	2.986
1985	0.917	0.825	0.610	0.543	0.840	3.278	5.027	5.818	5.938	2.326	1.453	1.067	2.387
1986	0.896	0.810	0.731	0.734	0.708	1.498	4.514	4.716	3.120	2.437	1.612	1.145	1.910
1987	0.866	0.717	0.715	-	-	-	-	-	-	-	-	-	0.766
Average	0.859	0.765	0.659	0.587	0.771	1.797	4.225	5.910	3.968	2.799	1.623	1.063	2.086
Minimum	0.430	0.394	0.360	0.328	0.503	0.652	1.792	2.098	2.619	1.790	1.162	0.867	1.083

Table II.2.3 MONTHLY MEAN DISCHARGE RECORDS (2/2)

Station Name : Nanglam
River Name : Kirang chu
Catchment Area : 51.65 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	-	-	-	-	-	-	12.720	9.354	10.921	8.818	6.807	4.018	8.773
1983	3.169	2.256	2.005	2.669	6.236	13.004	19.105	16.606	24.019	6.590	6.425	4.027	8.760
1984	3.936	3.714	3.744	3.932	25.008	13.365	36.618	9.068	9.472	2.705	1.237	1.068	9.489
1985	0.914	1.333	1.596	2.398	5.871	12.422	13.206	7.519	7.153	5.238	2.355	1.656	5.138
1986	0.992	0.727	0.549	0.854	1.155	4.489	7.717	6.081	6.138	3.269	1.723	1.055	2.896
1987	0.759	0.639	0.702	-	-	-	-	-	-	-	-	-	0.700
Average	1.954	1.734	1.719	2.463	9.568	10.820	17.873	9.726	11.541	5.324	3.509	2.365	6.550
Minimum	0.759	0.639	0.549	0.854	1.155	4.489	7.717	6.081	6.138	2.705	1.237	1.055	2.782

Station Name : Bangtar
River Name : Baranadi chu
Catchment Area : 973.6 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1982	-	-	9.340	20.181	24.332	42.250	-	31.972	35.115	22.564	29.311	18.238	25.923
1983	14.108	12.697	22.375	17.272	-	-	-	-	-	-	-	-	16.613
1984	-	-	-	-	31.460	53.414	78.681	-	139.775	81.832	22.346	15.138	60.378
1985	11.392	10.466	11.391	16.802	42.005	108.024	147.129	92.565	82.227	42.417	27.425	18.227	50.839
1986	15.319	14.115	12.934	21.978	20.989	43.331	111.868	101.042	86.312	62.288	28.192	20.579	44.912
Average	13.606	12.426	14.010	19.058	29,697	61.755	112.559	75.193	85.857	52.275	26.819	18.046	43.442
Minimum	11.392	10.466	9.340	16.802	20.989	42.250	78.681	31.972	35.115	22.564	22.346	15.138	26.421

Station Name : Chumey
River Name : Khangang chu
Catchment Area : 167.95 km^2

(Unit: m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
1983	3.278	3.228	3.445	4.313	8.586	6.243	10.960	6.822	5.181	5.662	3.346	2.893	5.330
1984	2.751	2.370	2.627	4.039	6.003	8.908	10.674	9.769	11.574	7.915	4.241	2.577	6.121
1985	2.281	2.574	2.483	3.180	4.511	5.921	13.537	9.474	11.750	-	-	4.895	6.061
Average	2.770	2.724	2.852	3.844	6.367	7.024	11.724	8.688	9.502	6.789	3.794	3.455	5.794
Minimum	2.281	2.370	2.483	3.180	4.511	5.921	10.674	6.822	5.181	5.662	3.346	2.577	4.584

Table II.2.4 MONTHLY RAINFALL RECORDS (1/2)

Station Name : Tashiyangtshi (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1986	-	2.00	19.60	95.30	61.40	203.30	302.60	159.00	255.20	96.40	17.30	1.50	(1,213.60)
1987	2.90	19.40	107.30	84.30	62.70	147.10	194.20	221.90	301.50	51.70	2.60	6.70	1,202.30
Average	2.90	10.70	63.45	89.80	62.05	175.20	248.40	190.45	278.35	74.05	9.95	4.10	1,209.40

Station Name : Khaling (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1982	-	-	-	-	-	-	192.30	190.50	66.25	55.00	16.00	8.00	(528.05)
1983	6.00	31.00	45.00	89.00	208.00	134.00	216.35	110.50	329.75	59.75	4.50	1.50	1,235.35
1984	29.25	7.00	6.75	61.75	197.16	224.50	287.70	152.80	276.00	71.40	20.00	18.00	1,352.31
1985	-	-	-	-	104.80	185.25	432.80	189.40	199.50	28.80	13.90	0.00	(1,154.45)
Average	17.63	19.00	25.88	75.38	169.99	181.25	282.29	160.80	217.88	53.74	13.60	6.88	1,224.29

Station Name : Tansebi (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	32.00	48.40	22.20	64.00	131.60	327.60	544.00	352.20	282.50	149.00	34.60	39.60	2,027.70
1986	3.60	8.20	35.20	151.80	112.80	412.60	407.80	215.60	285.80	99.80	8.80	11.60	1,753.60
1987	8.80	13.80	115.46	68.80	74.25	289.50	461.90	397.50	475.20	112.20	0.00	1.000	2,018.41
Average	14.80	23.47	57.62	94.87	106.22	343.23	471.23	321.77	347.83	120.33	14.47	17.40	1,933.24

Station Name : Pemagatshel (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1986	-	16.00	15.10	452.70	76.90	504.10	356.80	303.80	144.10	118.10	30.00	0.00	(2,017.60)
1987	1.00	21.00	16.90	-	-	-	-	-	-	-	-	-	(38.90)
Average	1.00	18.50	16.00	452.70	76.90	504.10	356.80	303.80	144.10	118.10	30.00	0.00	2,022.00

Station Name : Nanglam (Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1982	-	-	-	-	-	-	221.00	171.50	365.75	32.50	29.75	58.00	(878.50)
1983	8.50	18.75	16.00	62.75	391.50	720.50	753.25	492.50	430.50	57.50	0.00	9.00	2,960.75
1984	16.00	3.75	8.50	169.50	415.50	415.00	961.25	207.25	854.00	142.00	0.00	43.50	3,236.25
1985	0.00	12.75	92.00	189.75	579.00	632.75	769.25	364.17	400.43	149.50	11.30	29.10	3,230.00
1986	6.40	10.50	10.60	288.61	178.80	703.80	628.80	715.20	403.90	193.20	31.60	5.30	3,176.71
1987	3.80	27.00	109.20	-	-	-	-	-	-	-	-	-	(140.00)
Average	6.94	14.55	47.26	177.65	391.20	618.01	666.71	390.12	490.92	114.94	14.53	28.98	2,961.82

Table II.2.4 MONTHLY RAINFALL RECORDS (2/2)

Station Name : Bangtar

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1982	-	-	25.00	269.60	197.50	-	-	194.00	305.75	64.50	12.50	19.00	(1,087.85)
1983	-	18.75	134.00	144.00	446.00	548.00	928.00	796.00	-	-	-	-	(3,014.75)
1984	-	-	-	-	-	-	970.50	343.75	1567.00	81.25	0.00	98.75	(3,061.25)
1985	9.50	16.25	172.25	178.00	949.70	797.90	675.50	178.00	459.23	27.73	22.00	0.00	3,486.06
1986	0.00	10.00	41.25	628.30	245.75	648.75	623.50	551.25	520.00	339.50	23.75	31.00	3,663.05
Average	4.75	15.00	93.13	304.98	459.74	664.88	799.38	412.60	713.00	128.25	14.56	37.19	3,647.44

Station Name : Chumey

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1981	-	-	28.00	88.25	82.60	130.75	256.75	180.25	118.25	-	-	-	(884.85)
1982	-	-	30.50	60.25	67.00	155.50	71.25	140.87	-	55.75	8.25	0.50	(589.87)
1983	0.00	14.77	24.25	58.50	109.75	109.50	51.00	107.25	144.25	22.25	0.50	0.00	642.02
1984	0.00	20.05	32.94	25.85	74.10	82.40	84.70	139.90	-	-	0.00	0.00	(459.94)
1985	-	-	0.00	29.50	42.00	0.00	202.70	135.80	87.70	-	0.00	0.00	(497.70)
Average	0.00	17.41	23.14	52.47	75.09	95.63	133.28	140.81	116.73	39.00	2.19	0.13	695.88

Station Name : Mongar (Kurizampa)

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1976	5.20	6.20	0.00	55.80	50.40	133.80	98.60	-	41.40	19.40	7.20	7.60	(425.60)
1977	0.00	1.40	26.20	84.80	68.60	74.00	44.00	119.40	104.40	30.20	15.80	0.00	568.80
1978	8.70	4.10	9.40	30.60	29.10	91.80	103.50	62.50	104.00	26.40	25.30	0.00	495.40
1979	0.00	9.60	0.40	20.50	3.50	47.60	184.80	51.10	34.20	32.10	0.00	7.70	391.50
1980	7.20	6.50	62.90	47.60	52.70	119.90	151.90	68.80	39.80	43.30	1.80	0.00	602.40
1981	17.90	17.70	34.50	38.40	46.60	65.90	117.30	44.70	49.00	0.00	0.00	16.50	448.50
1982	0.00	8.10	52.90	59.20	63.40	137.10	138.70	136.70	45.40	33.30	11.50	0.00	686.30
1983	0.00	1.50	10.70	8.70	63.20	50.20	115.10	35.60	21.40	-	-	-	(306.40)
1984	-	-	-	-	42.90	136.10	137.70	106.90	224.00	14.20	0.00	0.00	(661.80)
1985	4.30	16.80	11.70	48.00	109.50	90.20	264.20	96.00	165.90	58.20	9.70	20.30	894.80
1986	0.00	8.20	16.00	118.80	30.80	240.40	192.80	99.00	39.20	0.00	3.00	1.80	750.00
1987	1.00	18.20	83.30	78.80	102.00	-	-	-	93.00	66.00	1.80	4.20	(448.30)
Average	4.03	8.94	28.00	53.75	55.23	107.91	140.78	82.07	80.14	29.37	6.92	5.28	602.41

Table II.2.5 CHARACTERISTICS OF RIVER BASIN

River Name	Station Name	Station El. (m)	Ridge El. (m)	Mean El. (m)	Difference El. (m)	River Length (km)	Mean Slope of River	Catchment Area at Station (km^2)	Mean Width of Basin
1. Birzam chu	T/Yangtshi	1,750	3,900	2,825	2,150	7.75	0.28	12.85	1.66
2. Jiri chu	Khaling	1,900	3,700	2,800	1,800	8.75	0.21	26.30	3.01
3. Uri chu	Pemagatshel	600	2,100	1,350	1,500	12.10	0.12	80.95	6.69
4. Khangang chu	Chumey	2,800	4,100	3,450	1,300	20.40	0.06	167.95	8.23
5. Kirang chu	Nanglam	400	2,000	1,200	1,600	19.20	0.08	51.65	2.69
6. Baranadi chu	Bangtar	300	4,200	2,250	3,900	102.60	0.04	973.60	9.49
7. Chendebji chu	Tansebi	1,800	5,000	3,400	3,200	44.20	0.07	429.30	9.71

Table II.2.6 SPECIFIC DISCHARGE OF VARIOUS RIVERS IN NEPAL

No.	Name of River	Name of Station	Catchment Area (km^2)	Discharge Mean/Min. (m^3/s)	Specific Discharge Mean/Min. (lit./s/km^2)	Observation Period (year)
1.	Narayani	Jurpani	80	5.0 2.0	63 25	1964-68
2.	Bagmati	Mahankal	14	1.1 0.7	79 50	1963-71
3.	Bagmati	Sundarijal	16	1.0 0.6	63 35	1963-72
4.	Bagmati	Gakrighat	68	3.1 1.4	46 21	1965-71
5.	Sapt Kosi	Panauti	87	2.4 1.6	28 19	1964-72

Table II.2.7 DROUGHT DISCHARGE ON PROJECT TRIBUTARIES

1) Lhuntshi District

(Unit: lit./s)

Tributary	Project Area	C.A. (km^2)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Paka chu	Pangkhar	0.25	2.6	2.4	2.2	2.7	3.9	5.0	7.7	5.9	4.5	4.2	4.0	3.2	4.0
Lekpagang chu	Gangzoor	8.60	88.6	81.7	74.8	91.1	135.0	172.0	264.0	202.1	153.9	144.5	137.6	110.1	137.8
Begang Sher chu	Tangmachhu/1	15.10	155.5	143.5	131.4	160.1	237.1	302.0	463.6	354.9	270.3	253.7	241.6	193.3	242.0
Narigang chu	Minji/1	36.20	372.9	343.9	314.9	383.7	568.3	724.0	1111.3	850.7	648.0	608.2	579.2	463.4	580.1
Begang chu	Menjibi	13.28	136.8	126.2	115.5	140.8	208.5	165.6	407.7	312.1	237.7	223.1	212.5	170.0	212.8
Dungkhar chu	Kupinesa	6.80	70.0	64.6	59.2	72.1	106.8	136.0	208.8	159.8	121.7	114.2	108.8	87.0	109.0
Kheba chu	Wambur	9.93	102.3	94.3	86.4	105.3	155.9	198.6	304.9	233.4	177.8	166.8	158.9	127.1	159.1

2) Mongar District

(Unit: lit./s)

Tributary	Project Area	C.A. (km^2)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Thruwan chu	Chali	3.53	36.4	33.5	30.7	37.4	55.4	70.6	108.4	83.0	63.2	59.3	56.5	45.2	57.6
Shongjari chu	Karibithang	21.90	225.6	208.1	190.5	232.1	343.8	438.0	672.3	514.7	392.0	367.9	350.4	280.3	350.9
Shongjari chu	Karibee/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shongjari chu	Masangdaza/1	22.00	226.6	209.0	191.4	233.2	345.4	440.0	675.4	517.0	393.8	369.6	352.0	281.6	352.6
Shongjari chu	Pangsibi/2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Drodi ri	Gyelposhing	13.88	143.0	131.9	120.8	147.1	217.9	277.6	426.1	326.2	248.5	233.2	222.1	177.7	222.4
Kalapang and Dabrang ri	Kalapang/1	4.03	41.5	38.3	35.1	42.7	63.3	80.6	123.7	94.7	72.1	67.7	64.5	51.6	64.6
Seri chu	Yadi	2.03	20.9	19.3	17.7	21.5	31.9	40.6	62.3	47.7	36.3	34.1	32.5	26.0	32.5
Goda and Loda ri	Chaskhar/1	3.73	38.4	35.4	32.5	39.5	58.6	74.6	114.5	87.7	66.8	62.7	59.7	47.7	59.8

Note: /1: Drought discharge at lower intake point.
/2: Drought discharge can't be assessed because of no intake point at present.

Table II.2.8 WATER QUALITY

Name of Tributary	Project Area	Electric Conductivity mhos/cm	pH
Lhutshi District			
1. Paka Chu	Pang Khar	32	7.4
2. Lekpagang chu	Gangzoor	75	8.0
3. Begang Sher and Ngeh chu	Tangmachhu	34	7.3
4. Narigang chu	Minji	31	7.5
5. Begang chu	Menjibi	34	7.3
6. Dungkhar chu	Kupinesa	29	7.6
7. Kheba chu	Wambur	33	7.7
Mongar District			
1. Thruwan chu	Chali	120	8.0
2. ShoNgjari chu	Karbithang Karibee Masangdaza Pangsibi	80	8.0
3. Drodi ri	Gyelposhing	61	7.8
4. Kalapang and Dubrang ri	Kalapang	-	-
5. Seri chu	Yadi	25	7.4
6. Goda and Loda ri	Chaskhar	48	7.7

Table II.2.9 DISCHARGE RECORDS ON JIRI CHU AND SPECIFIC DISCHARGE

(Unit: m3/s)

Month	Day	1981	1982	1983	1984	1985	Mean	Min.	Specific Discharge to be applied (l/s/km2) Mean	Drought
Jan.	1 - 10	-	1.194	0.797	0.508	0.665	0.791	0.508	16.4	10.5
	11 - 20	-	1.367	0.718	0.516	0.646	0.812	0.516	16.8	10.7
	21 - 31	-	1.373	0.707	0.460	0.648	0.797	0.460	16.5	9.5
Feb.	1 - 10	-	1.048	0.703	0.479	0.492	0.681	0.479	14.1	9.9
	11 - 20	-	0.696	0.694	0.466	0.514	0.593	0.466	12.3	9.7
	21 - 28	-	0.723	0.703	0.420	0.579	0.606	0.420	12.6	8.7
Mar.	1 - 10	-	0.820	0.671	0.426	0.927	0.711	0.426	14.8	8.8
	11 - 20	-	0.782	0.764	0.430	0.767	0.686	0.430	14.2	8.9
	21 - 31	-	0.659	0.777	0.402	0.749	0.647	0.402	13.4	8.3
Apr.	1 - 10	-	1.239	0.816	0.503	0.937	0.874	0.503	18.1	10.4
	11 - 20	1.744	0.860	0.801	0.422	1.178	1.001	0.422	20.8	8.8
	21 - 30	1.658	0.980	0.696	0.606	1.268	1.042	0.606	21.6	12.6
May	1 - 10	1.744	1.024	1.185	0.598	1.646	1.239	0.598	25.7	12.4
	11 - 20	1.712	1.028	0.923	0.810	1.392	1.173	0.810	24.3	16.8
	21 - 31	1.831	0.850	0.893	0.848	1.386	1.162	0.848	24.1	17.6
Jun.	1 - 10	1.753	1.319	0.913	2.042	2.003	1.606	0.913	33.3	18.9
	11 - 20	1.906	1.416	0.915	2.544	1.560	1.668	0.915	34.6	19.0
	21 - 30	4.055	1.560	1.057	2.449	1.828	2.190	1.057	45.4	21.9
Jul.	1 - 10	5.621	1.417	2.657	2.746	2.147	2.918	1.417	60.5	29.4
	11 - 20	7.325	1.493	2.170	2.114	2.764	3.173	1.493	65.8	31.0
	21 - 31	5.898	1.504	1.792	3.625	4.390	3.442	1.504	71.4	31.2
Aug.	1 - 10	4.901	1.426	1.737	2.533	2.923	2.704	1.426	56.1	29.6
	11 - 20	4.156	1.030	1.594	2.064	2.190	2.207	1.030	45.8	21.4
	21 - 31	3.420	0.929	1.808	2.875	2.514	2.309	0.929	47.9	19.3
Sep.	1 - 10	2.902	0.845	2.133	4.696	3.014	2.718	0.845	56.4	17.5
	11 - 20	3.630	0.924	5.033	3.255	2.543	3.077	0.924	63.8	19.2
	21 - 30	2.640	0.822	2.218	1.573	2.099	1.870	0.822	38.8	17.1
Oct.	1 - 10	2.082	0.779	1.335	1.440	1.578	1.443	0.779	29.9	16.2
	11 - 20	1.680	0.751	1.232	1.299	1.517	1.296	0.751	26.9	15.6
	21 - 31	1.550	0.886	1.180	1.193	1.346	1.231	0.886	25.5	18.4
Nov.	1 - 10	1.618	0.840	0.776	1.084	1.268	1.117	0.776	23.2	16.1
	11 - 20	1.492	0.807	0.768	1.042	-	1.027	0.768	21.3	15.9
	21 - 30	1.435	0.773	0.769	0.965	-	0.986	0.769	20.5	16.0
Dec.	1 - 10	1.329	0.815	0.685	0.859	-	0.922	0.685	19.1	14.2
	11 - 20	1.351	0.821	0.627	0.801	-	0.900	0.627	18.7	13.0
	21 - 31	1.240	0.768	0.545	0.698	-	0.813	0.545	16.9	11.3
Average		2.675	1.017	1.214	1.426	1.576	1.471	0.771	30.5	16.0

Table II.2.10 AVAILABLE DISCHARGE OF THE MODEL PROJECT AREA

(Unit: l/s)

Project Area		Tangmachhu Area						Masangdaza Area			
Name of Intake		Tangmachhu No. 1		Tangmachhu No. 2		Gorgan		Masangdaza		Bongdima/Karbithang	
Month	Day	Mean	Drought	Mean	Drought	Mean	Drought	Mean	Drought	Mean	Drought
Jan.	1 - 10	89	57	74	47	248	159	249	160	361	231
	11 - 20	91	58	76	48	254	162	255	163	370	235
	21 - 31	89	51	74	43	249	143	251	144	363	209
Feb.	1 - 10	76	53	63	45	213	149	214	150	310	218
	11 - 20	66	52	55	44	186	146	187	147	271	213
	21 - 28	68	47	57	39	190	131	192	132	277	191
Mar.	1 - 10	80	48	67	40	223	133	225	134	326	194
	11 - 20	77	48	64	40	214	134	216	135	314	196
	21 - 31	72	45	60	37	202	125	204	126	295	183
Apr.	1 - 10	98	56	81	47	273	157	275	158	398	229
	11 - 20	112	48	94	40	314	133	316	134	458	194
	21 - 30	117	68	97	57	326	190	328	192	475	277
May	1 - 10	139	67	116	56	388	187	391	188	565	273
	11 - 20	131	91	109	76	367	254	369	255	535	370
	21 - 31	130	95	108	79	364	266	366	268	530	387
Jun.	1 - 10	180	102	150	85	503	285	506	287	733	416
	11 - 20	187	103	156	86	522	287	526	289	761	418
	21 - 30	245	118	204	99	686	331	690	333	999	482
Jul.	1 - 10	327	159	272	132	914	444	920	447	1,331	647
	11 - 20	355	167	296	140	994	468	1,000	471	1,448	682
	21 - 31	386	168	321	140	1,078	471	1,085	474	1,571	686
Aug.	1 - 10	303	160	252	133	847	447	853	450	1,234	651
	11 - 20	247	116	206	96	692	323	696	325	1,008	471
	21 - 31	259	104	216	87	723	291	728	293	1,054	425
Sep.	1 - 10	305	95	254	79	852	264	857	266	1,241	385
	11 - 20	345	104	287	86	963	290	970	292	1,404	422
	21 - 30	210	92	175	77	586	258	590	260	854	376
Oct.	1 - 10	161	87	135	73	451	245	454	246	658	356
	11 - 20	145	84	121	70	406	236	409	237	592	343
	21 - 31	138	99	115	83	385	278	388	280	561	405
Nov.	1 - 10	125	87	104	72	350	243	353	245	510	354
	11 - 20	115	86	96	72	322	240	324	242	469	350
	21 - 30	111	86	92	72	310	242	312	243	451	352
Dec.	1 - 10	103	77	86	64	288	214	290	216	420	312
	11 - 20	101	70	84	59	282	196	284	198	411	286
	21 - 31	91	61	76	51	255	171	257	172	372	249

Table II.2.11 DISCHARGE MEASUREMENT RESULT

Project Area	Tributary	Date	Measured Discharge (m3/s)	Estimated Mean (m3/s)
Tangmachhu	Begang Sher chu	19.3.88	0.316	0.214
		23.7.88	1.424	
		30.7.88	0.886	
		Av.	1.155	1.078
		8.8.88	0.852	0.847
Masangdaza	Shongjari chu	18.3.88	0.267	0.314
		19.7.88	0.770	1.448
		26.7.88	2.009	1.571
		2.8.88	1.435	
		3.8.88	1.271	
		9.8.88	0.818	
		Av.	1.175	1.234

Table II.2.12 PARAMETERS FOR FLOOD DISCHARGE ESTIMATE

1) River Characteristics

Project Area	Name of Intake	Catchment Area (km^2)	Length of Main Stream (km)	El. at Intake (m)	El. at Ridge (m)	Average Slope (%)
Tangmachhu	Tangmachhu No. 1	5.4	3.10	2,230	3,600	41.3
	Tangmachhu No. 2	4.5	5.10	2,205	3,800	31.3
	Gorgan	15.1	6.70	1,955	3,800	27.5
Masangdaza	Masangdaza	15.2	6.25	920	2,800	23.7
	Bongdima/Karbithang	22.0	7.30	800	2,800	21.6

2) Flood Concentration Time (tc)

(Unit: hr)

Project Area	Name of Intake	Blansby-Williams	Ramser-Kirpich	Rziha
Tangmachhu	Tangmachhu No. 1	0.76	0.22	0.07
	Tangmachhu No. 2	1.34	0.36	0.14
	Gorgan	1.61	0.47	0.20
Masangdaza	Masangdaza	1.54	0.47	0.18
	Bongdima/Karbithang	1.77	0.55	0.22

Note: Blansby-Williams $tc = 0.61 \times L/(A^{0.1} \times S^{0.2})$
Ramser-Kirpich $tc = 0.0019 \times (L/S^{0.5})^{0.77}$
Rziha $tc = L/W,\ W = 72 \times (H/L)^{0.6}$

3) Rainfall Intensity and Peak Runoff Coefficient

Project Area	Name of Intake	Rainfall Intensity (mm/hr) Return Period in Years 2	5	10	25	50	Runoff Coefficient
Tangmachhu	Tangmachhu No. 1	9.0	11.6	13.0	15.4	16.9	0.66
	Tangmachhu No. 2	7.2	9.3	10.5	12.3	13.5	0.64
	Gorgan	6.7	8.7	9.8	11.5	12.5	0.63
Masangdaza	Masangdaza	6.8	8.8	9.9	11.7	12.7	0.62
	Bongdima/Karbithang	6.5	8.4	9.6	11.1	12.2	0.61

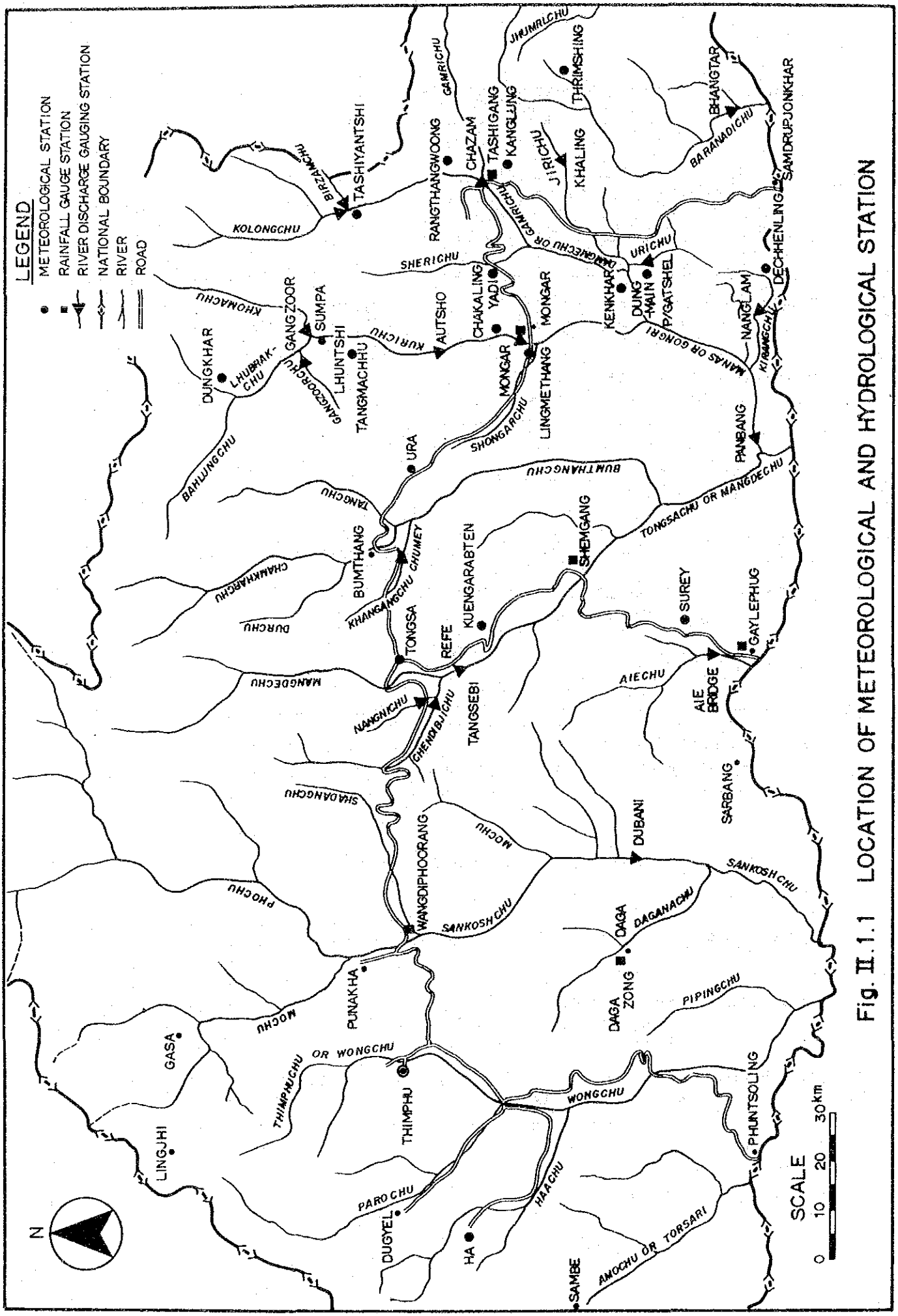


Fig. II.1.1 LOCATION OF METEOROLOGICAL AND HYDROLOGICAL STATION

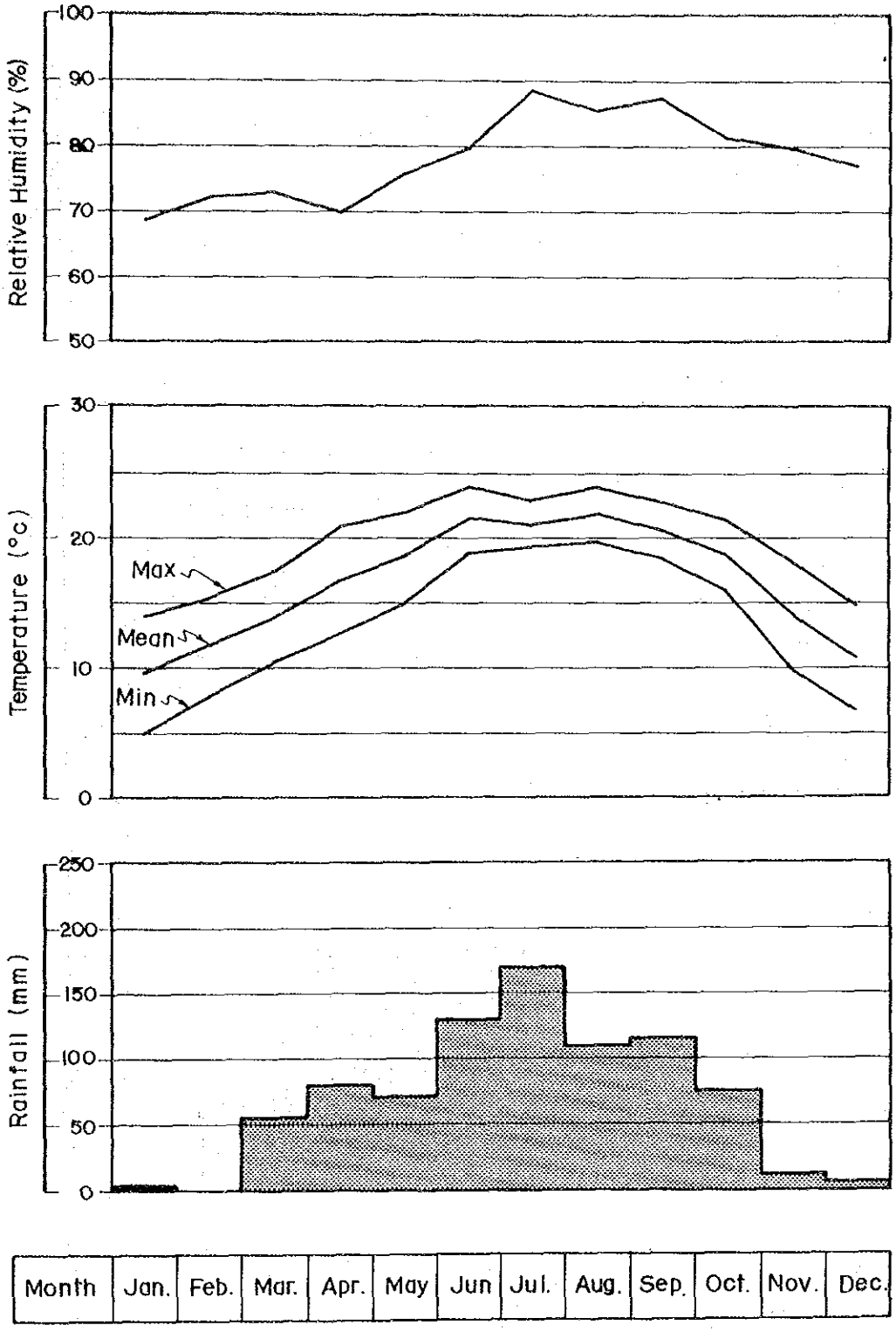


Fig. II.1.2 MONTHLY METEOROLOGICAL RECORD (1/2)
(TANGMACHHU AREA)

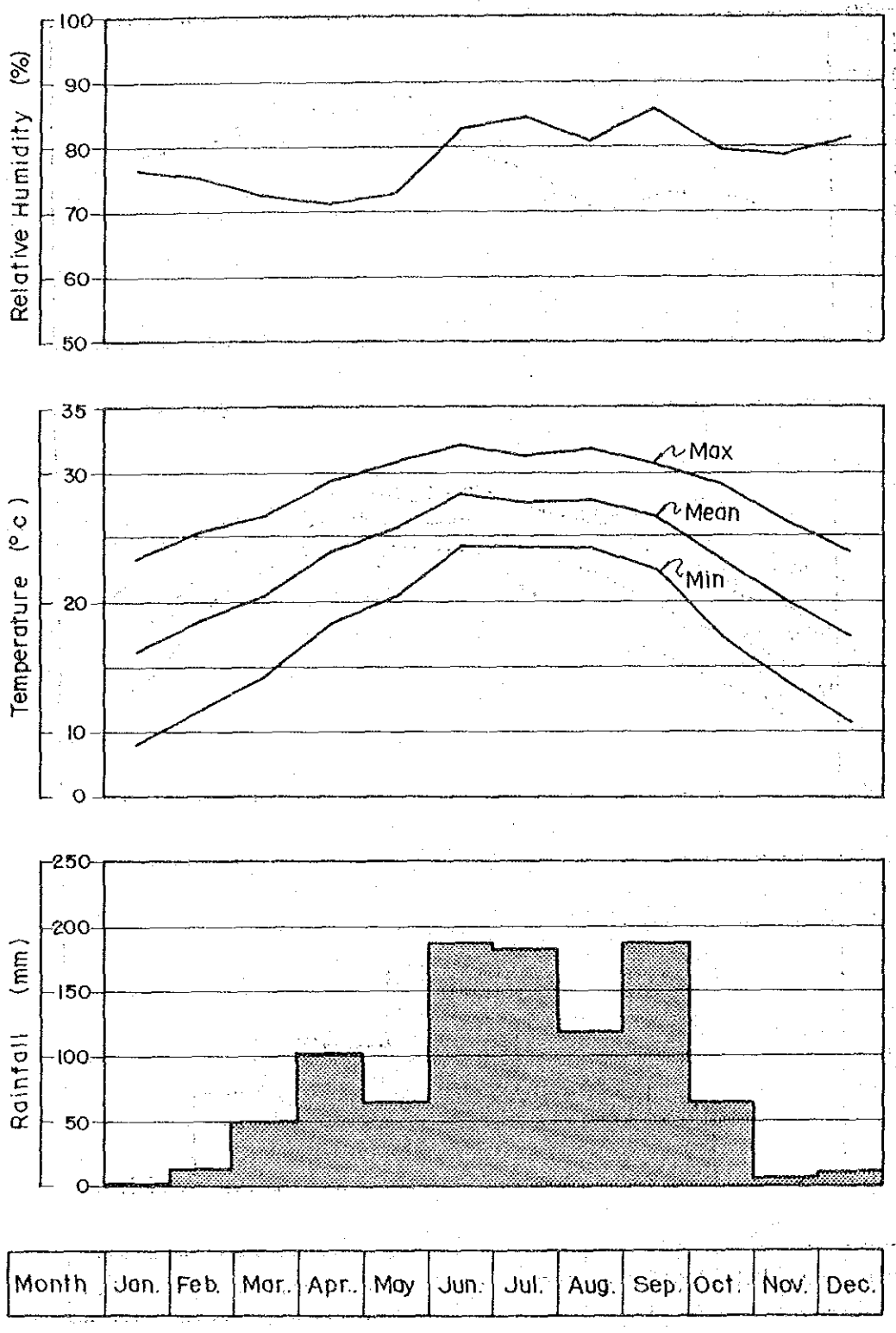


Fig. II. 1. 2 MONTHLY METEOROLOGICAL RECORD (2/2)
(MASANGDAZA INTEGRATED AREA)

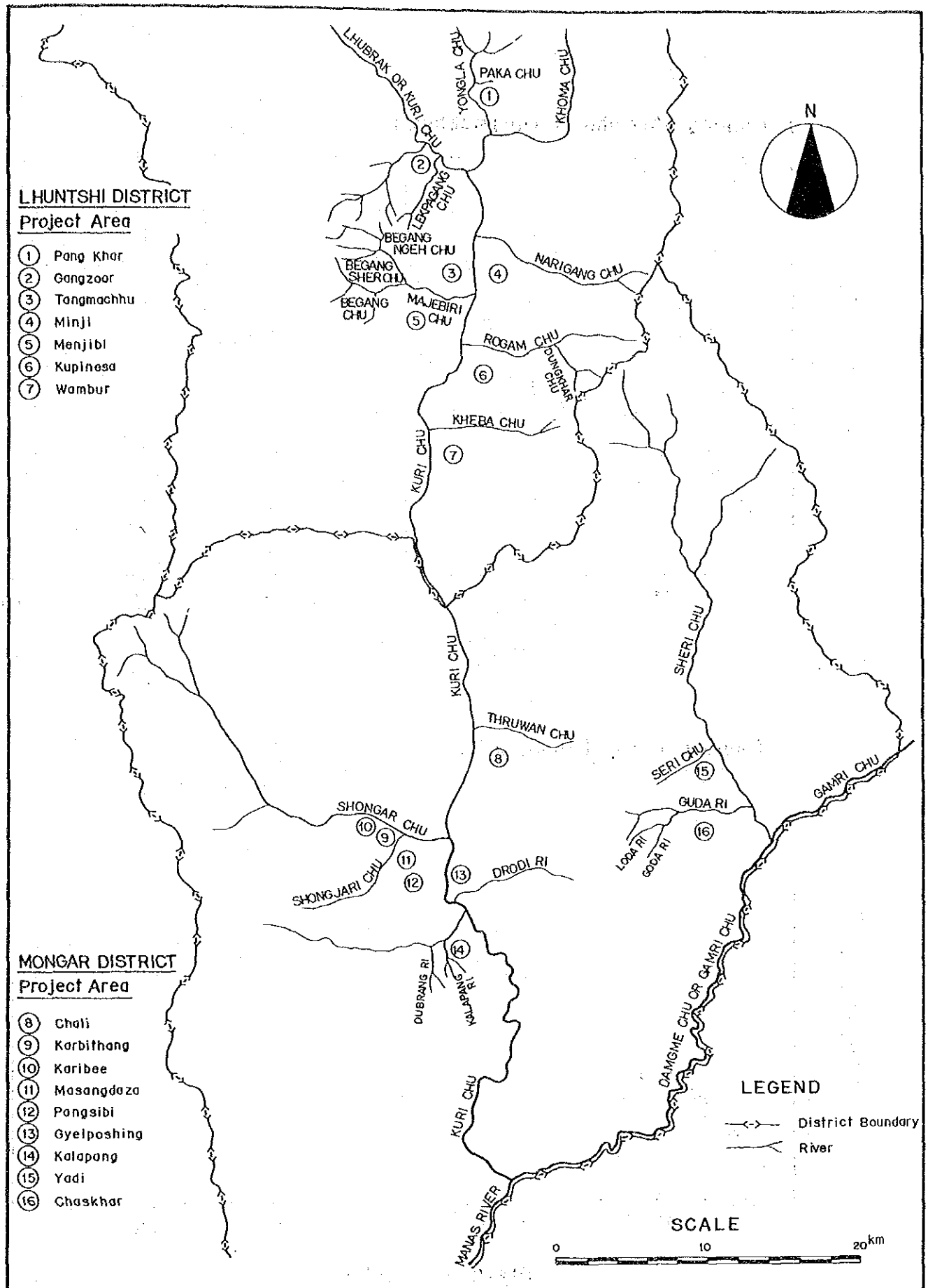
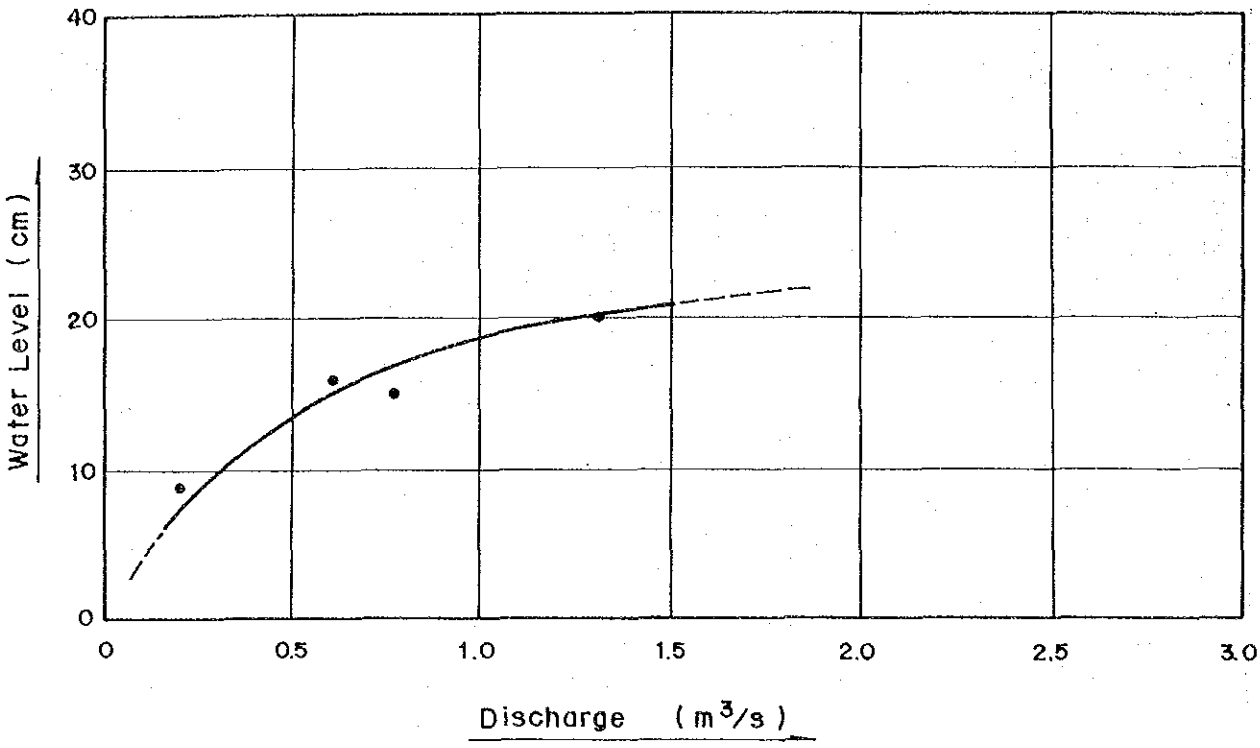


Fig.II.2.1 RIVER SYSTEM

1) Begang Sher chu (Tangmachhu)



2) Shongjari chu (Masangdaza)

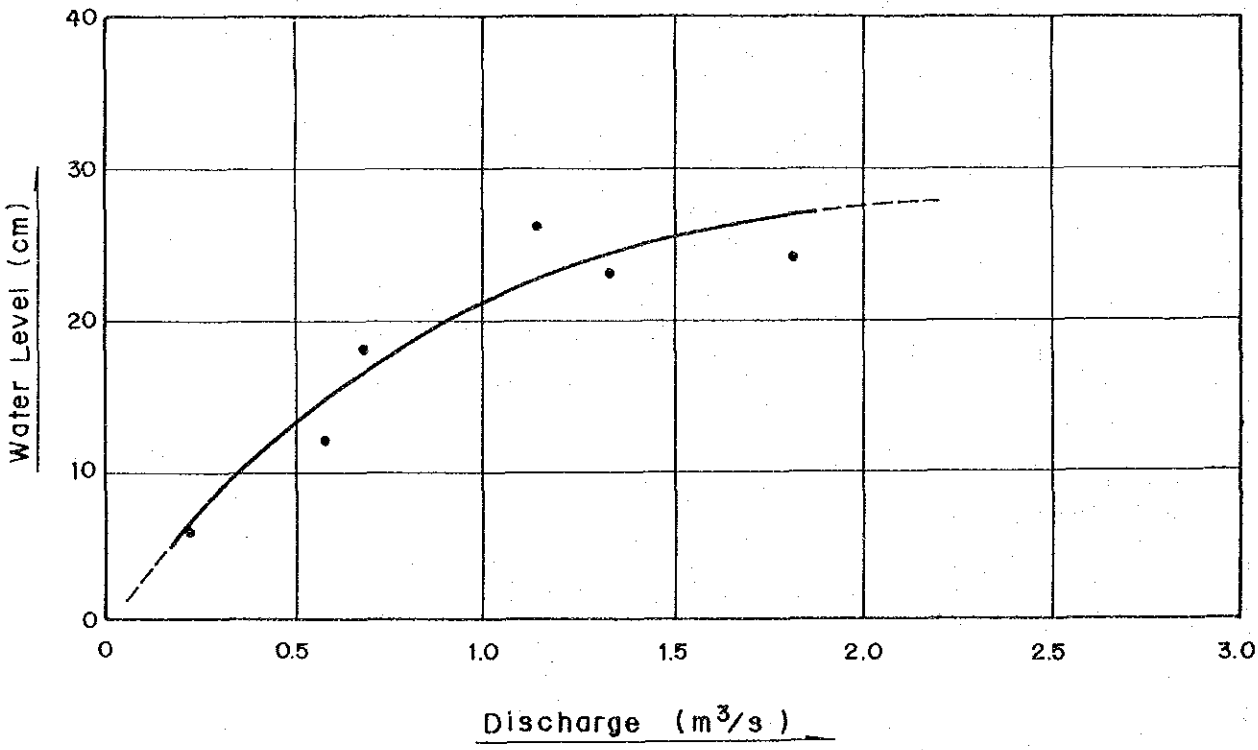
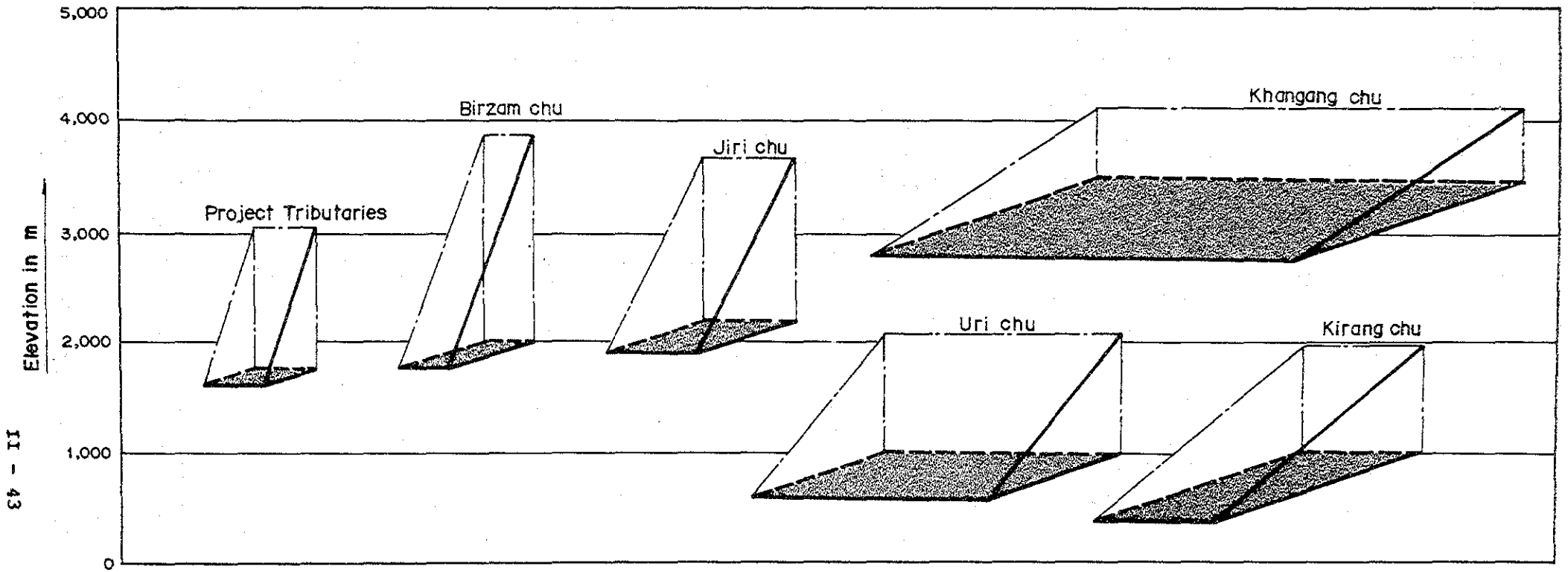
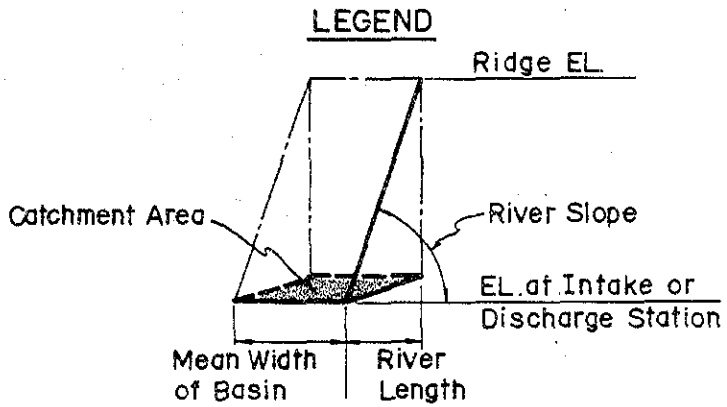


Fig.II.2.2 RATING CURVE FOR PROJECT TRIBUTARY





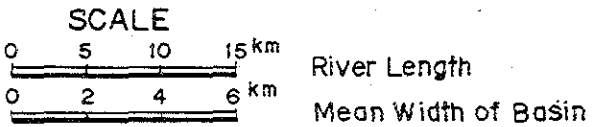
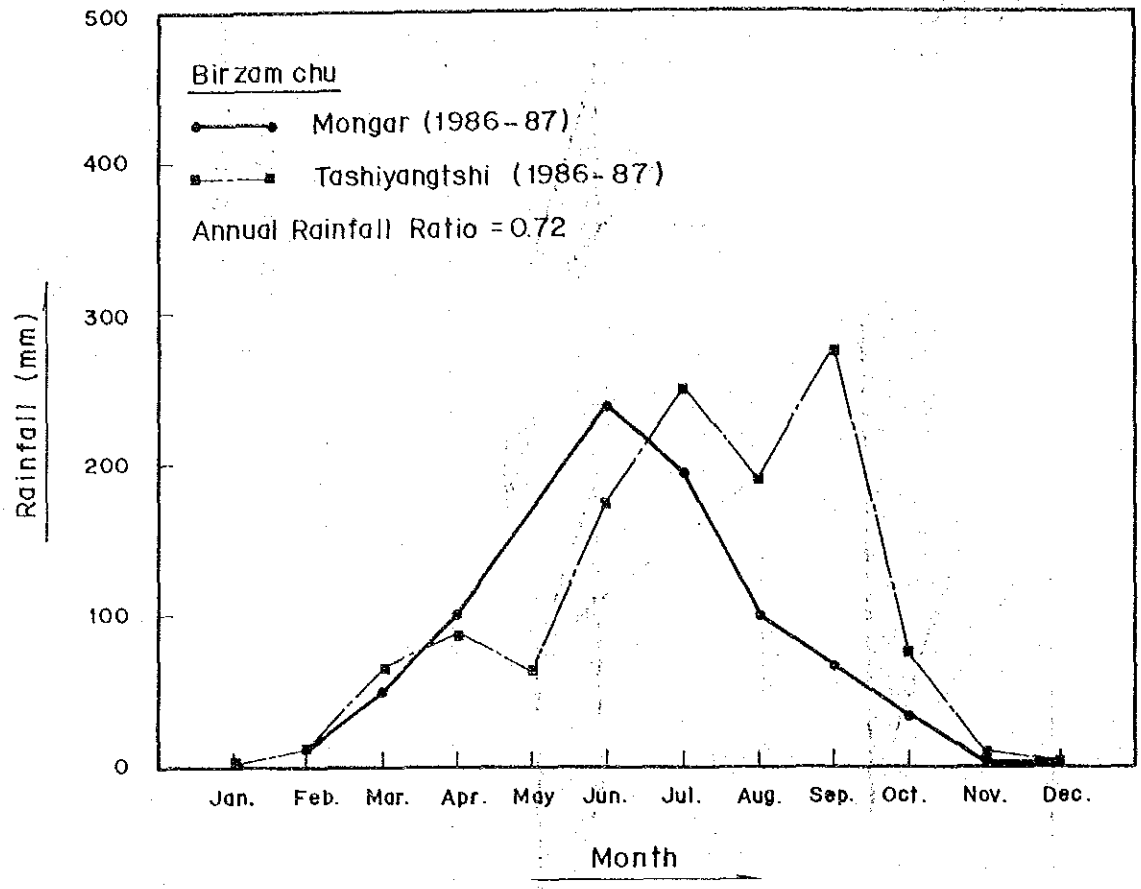


Fig. II.2.3 COMPARISON OF RIVER BASIN CHARACTRISTICS



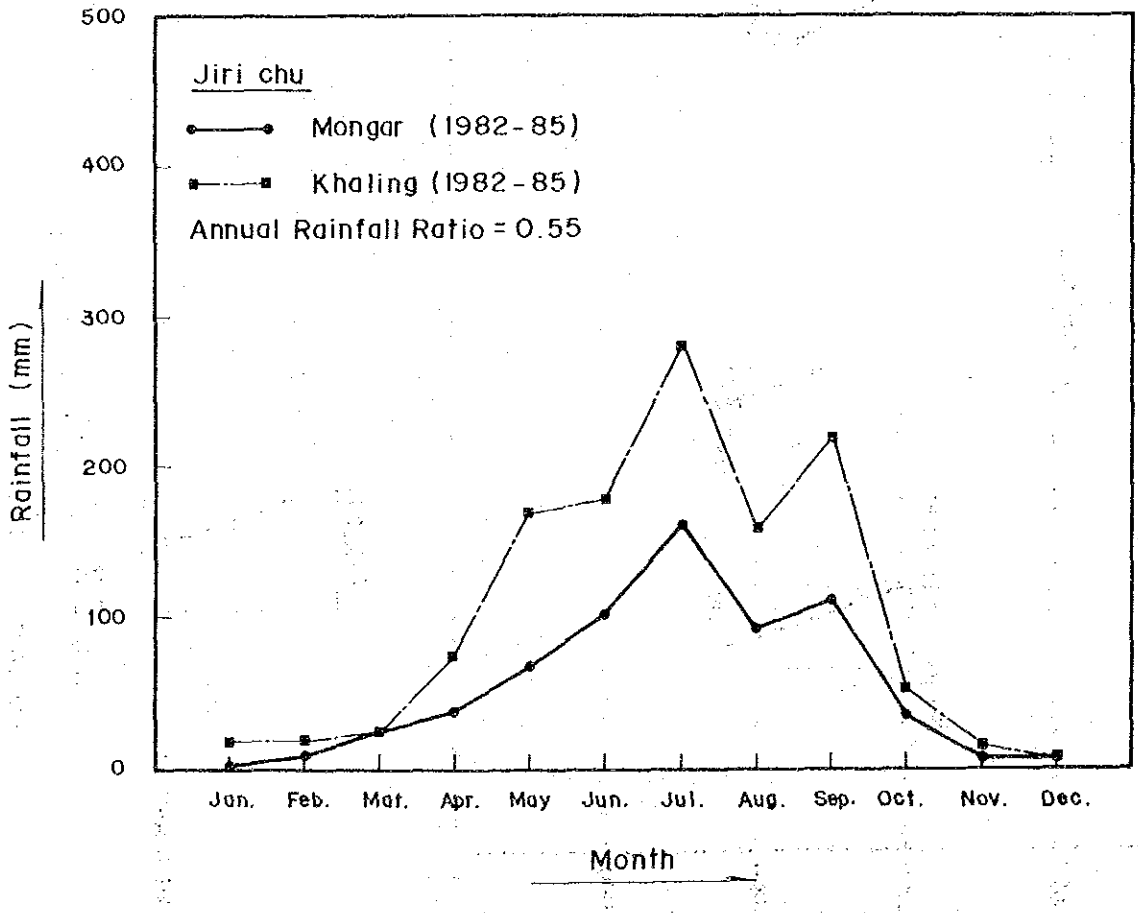
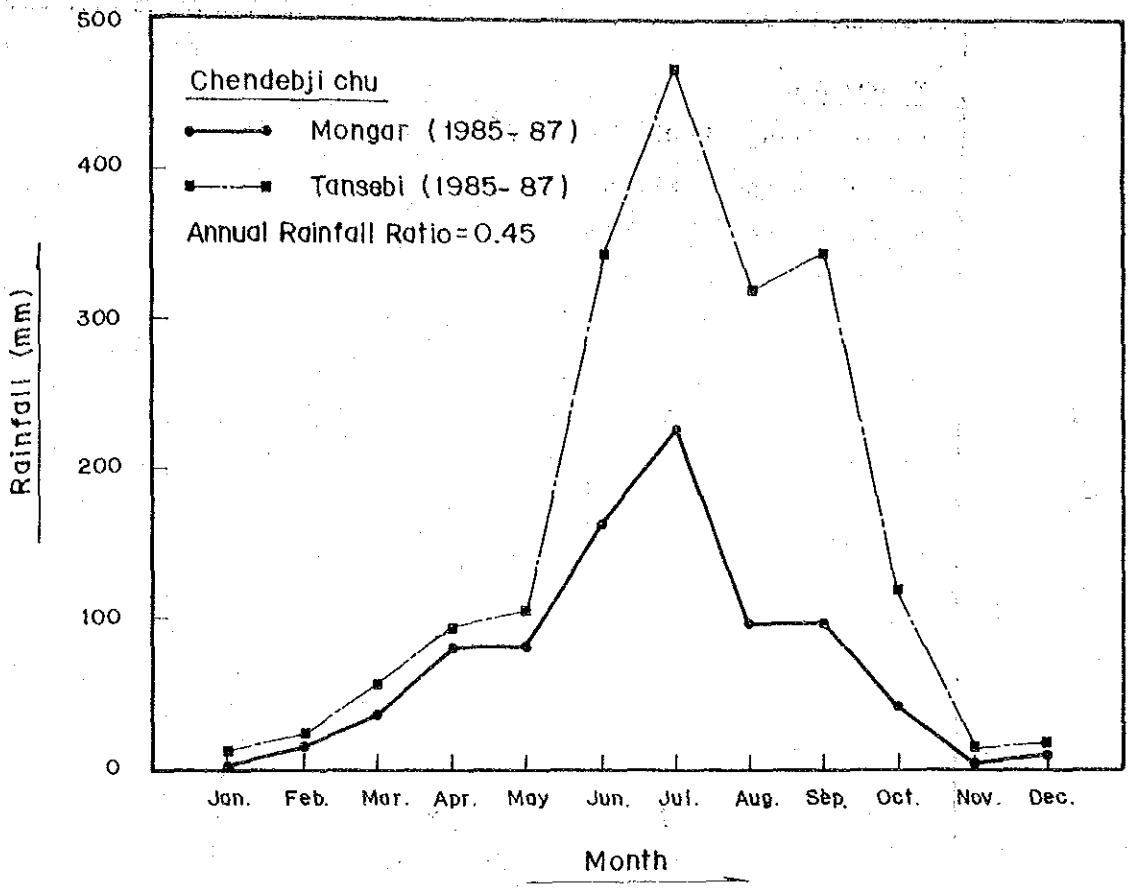


Fig.II.2.4 RAINFALL DISTRIBUTION PATTERN (1/4)



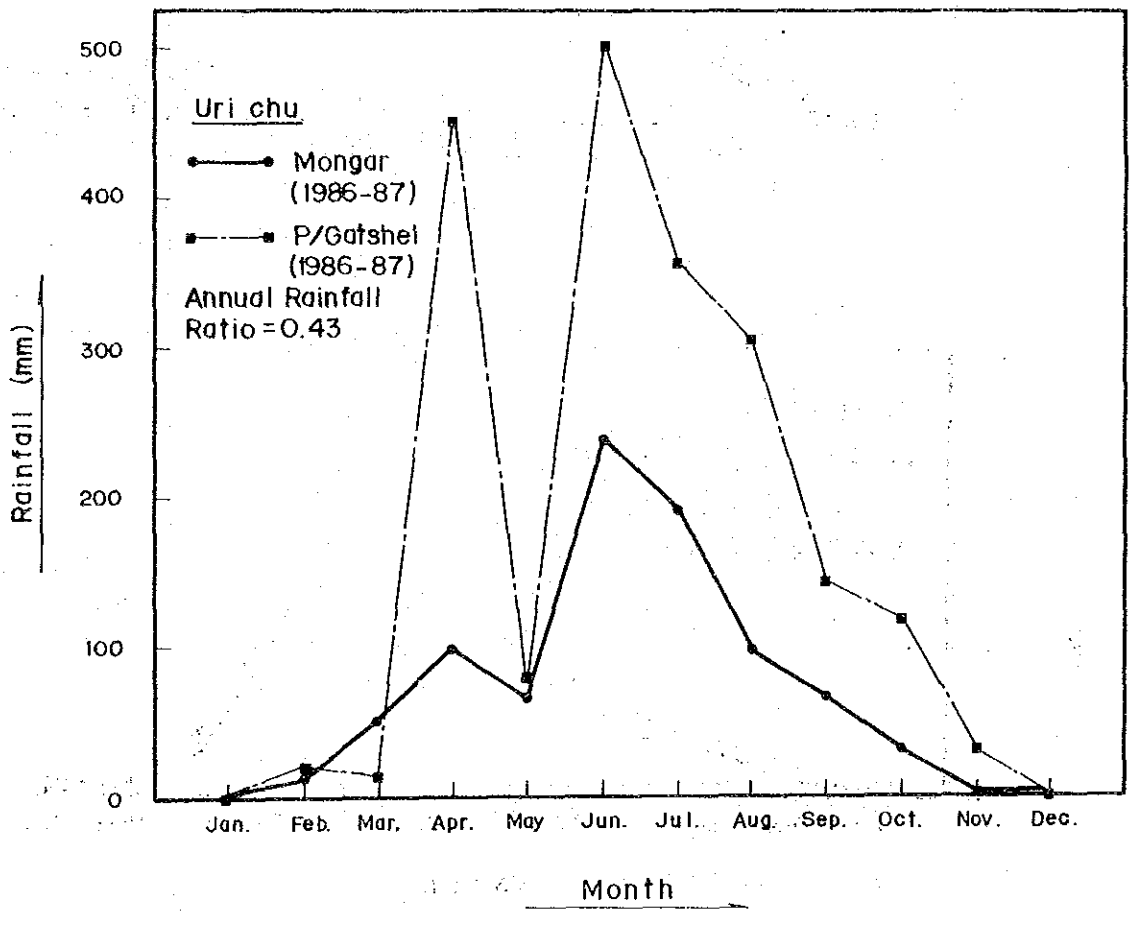
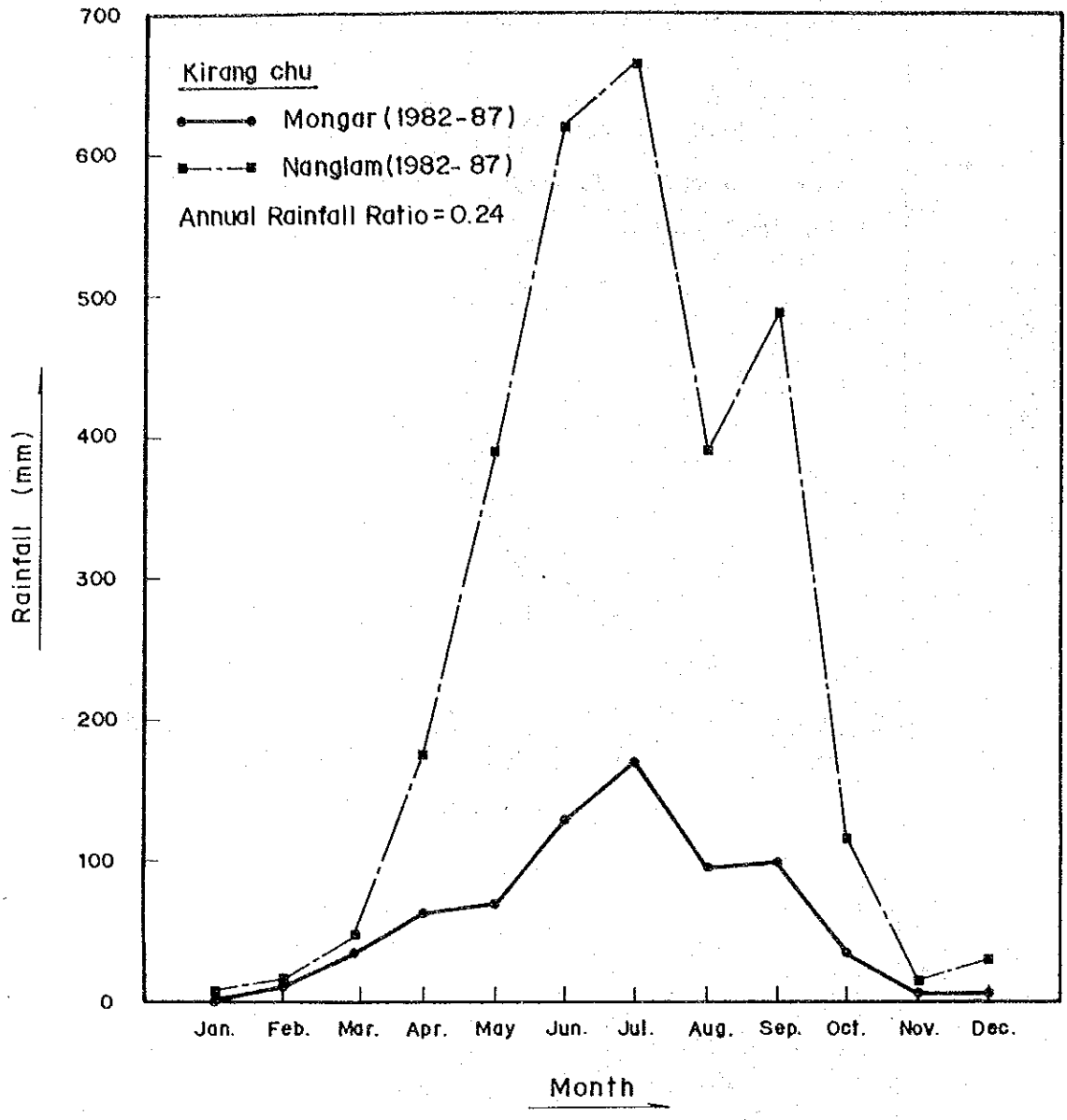


Fig.II.2.4 RAINFALL DISTRIBUTION PATTERN (2/4)



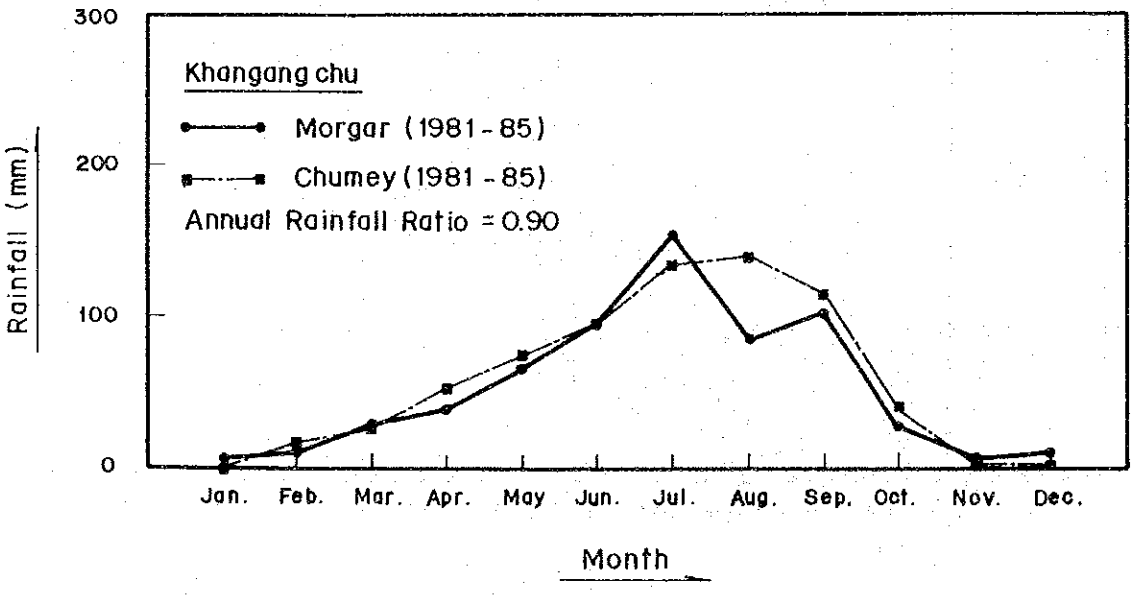


Fig. II. 2.4 RAINFALL DISTRIBUTION PATTERN (3/4)

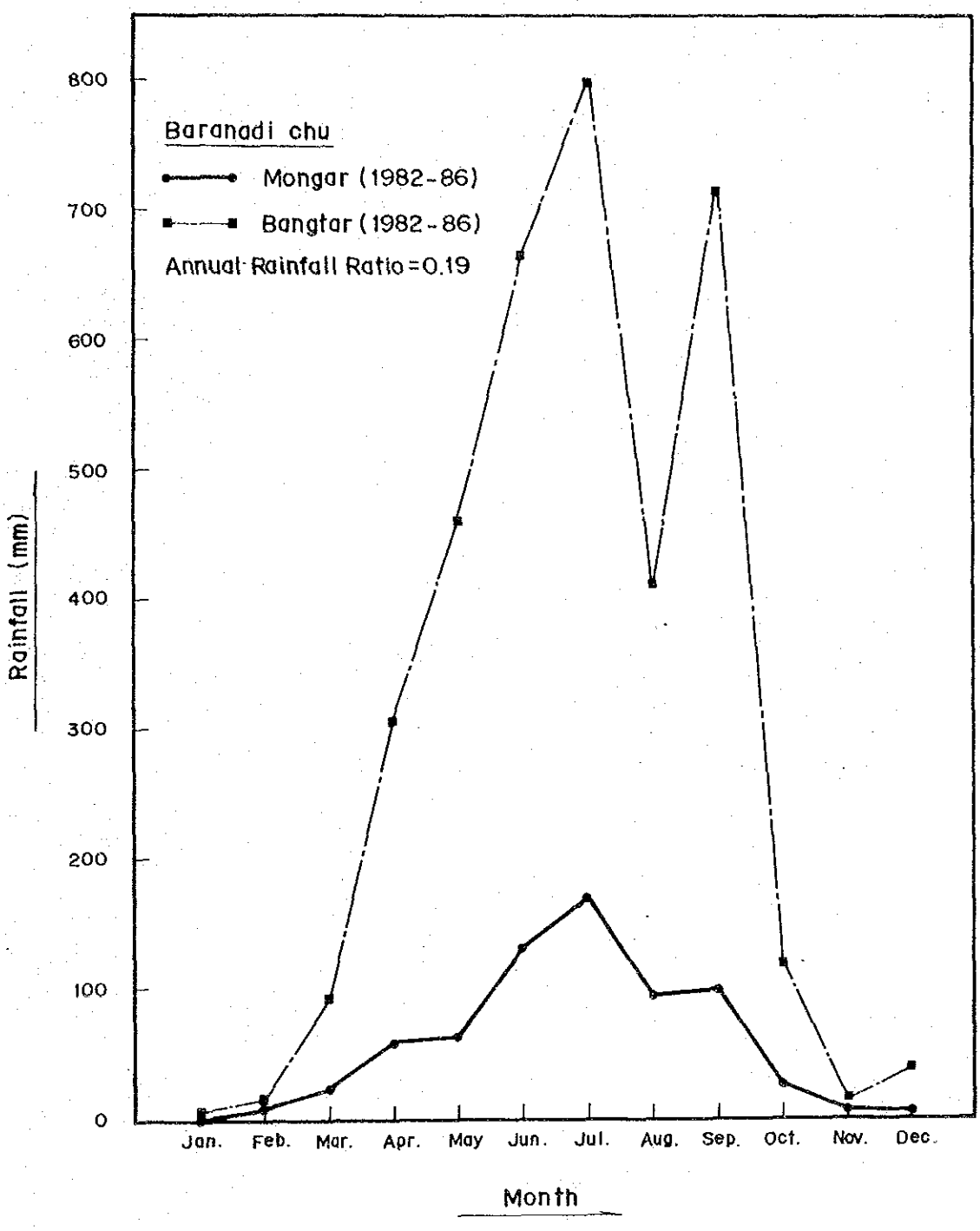


Fig.II.2.4 RAINFALL DISTRIBUTION PATTERN (4/4)

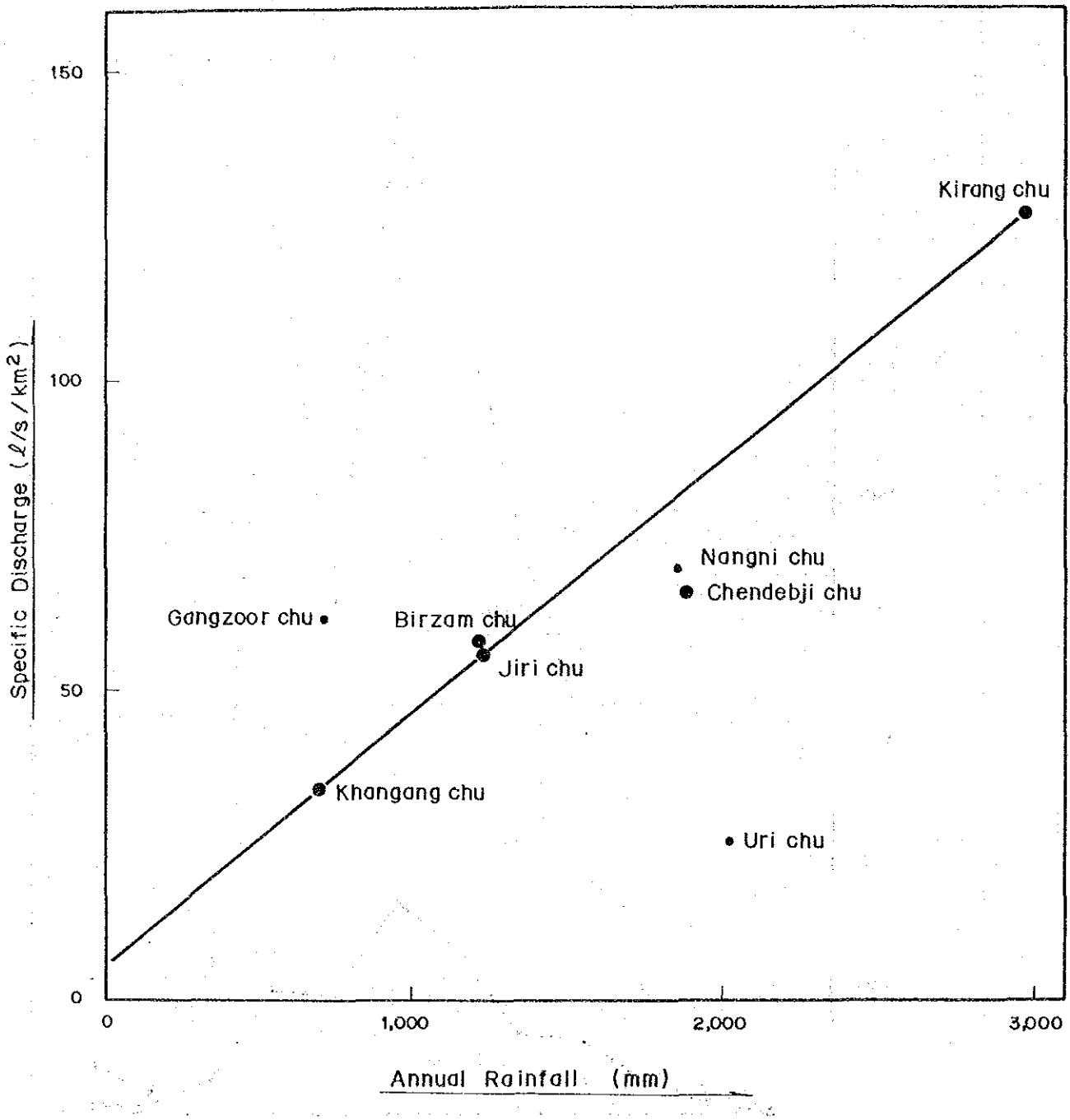


Fig. II. 2.5 RELATIONSHIP BETWEEN SPECIFIC DISCHARGE AND ANNUAL RAINFALL.

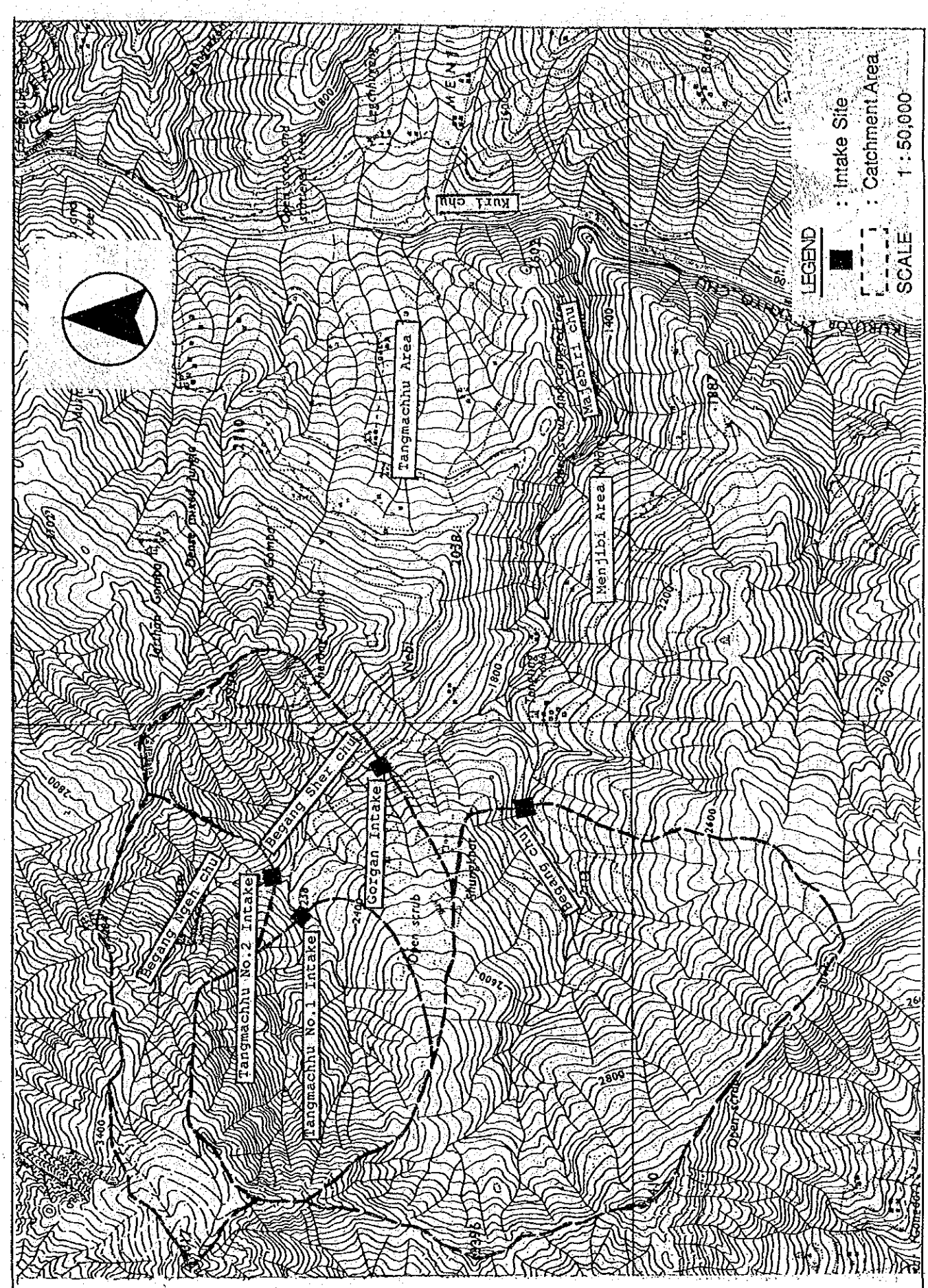


Fig.II.2.6 CATCHMENT AREA AT INTAKE SITE (1/2)
(TANGMACHHU AREA)

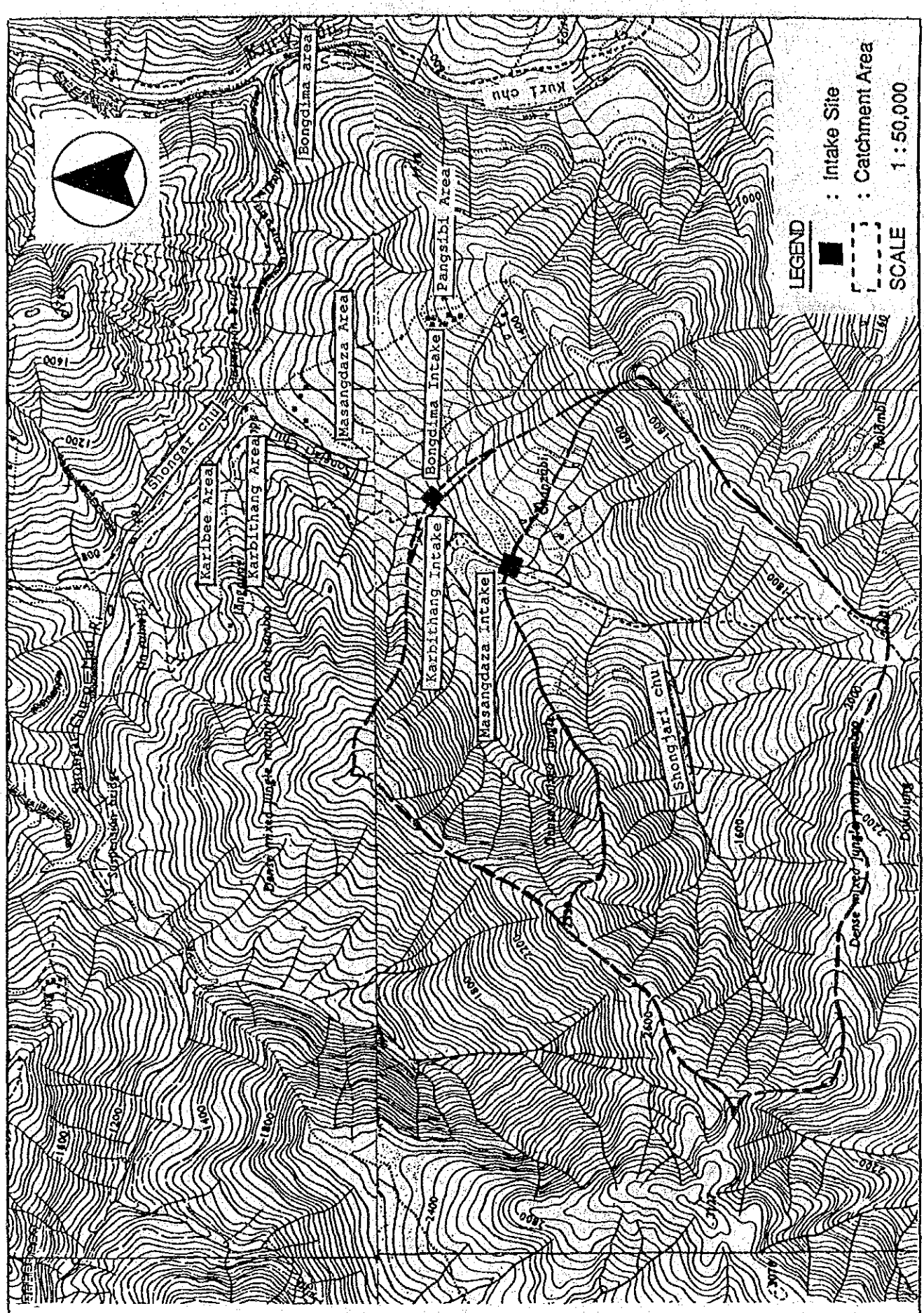
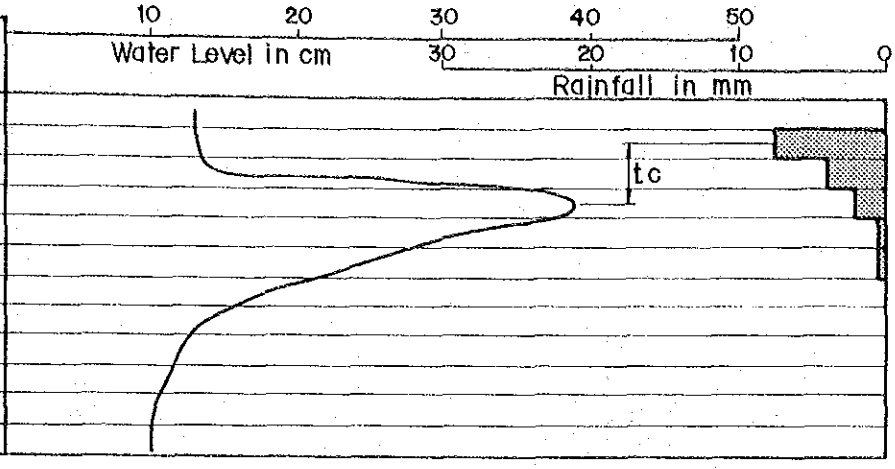


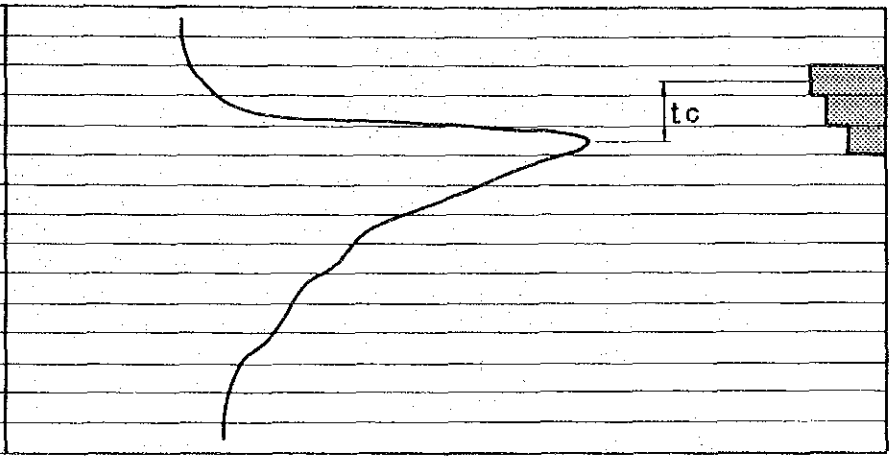
Fig.II.2.6 CATCHMENT AREA AT INTAKE SITE (2/2)
(MASANGDAZA INTEGRATED AREA)

1) Tangmachhu

Time Date	Hour	Rain-fall	Water Level
31st Jul.	16	0	13
	17	7.5	13
	18	4.0	14
	19	2.0	39
	20	0.5	32
	21	0.5	25
	22	0	18
	23	0	14
	24	0	12
1st Aug.	1	0	11
	2	0	10
	3	0	10

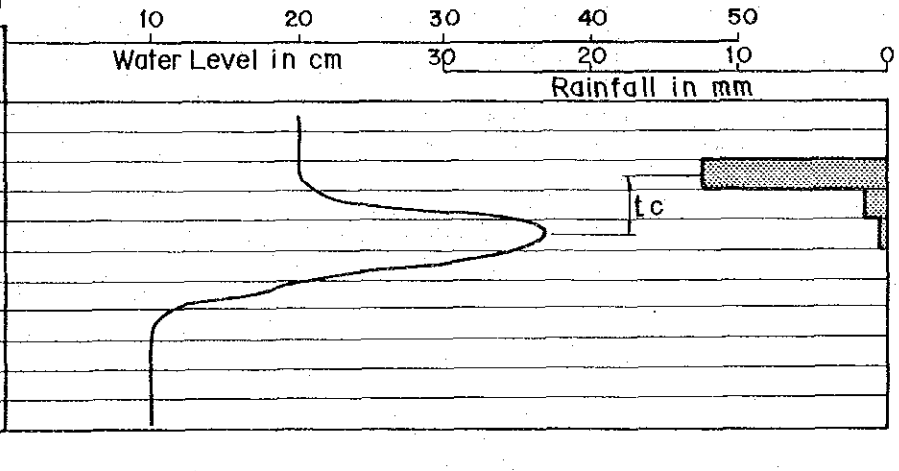


17th Jul.	17	0	12
	18	0	12
	19	5.0	13
	20	4.0	16
	21	2.5	40
	22	0	35
	23	0	30
	24	0	25
18th Jul.	1	0	23
	2	0	20
	3	0	19
	4	0	17
	5	0	16
	6	0	15
	7	0	15



2) Masangdaza

Time Date	Hour	Rain-fall	Water Level
20th Jul.	16	0	20
	17	0	20
	18	12.5	20
	19	1.5	25
	20	0.5	37
	21	0	30
	22	2.0	20
	23	0	15
	24	0	10
21st Jul.	1	0	10
	2	0	10



10th Jul.	20	0	21
	21	0	21
	22	0	21
	23	11.5	23
	24	13.5	28
11th Jul.	1	2.5	34
	2	0	35
	3	0	34
	4	0	33
	5	0	32
	6	0	30
	7	0	28

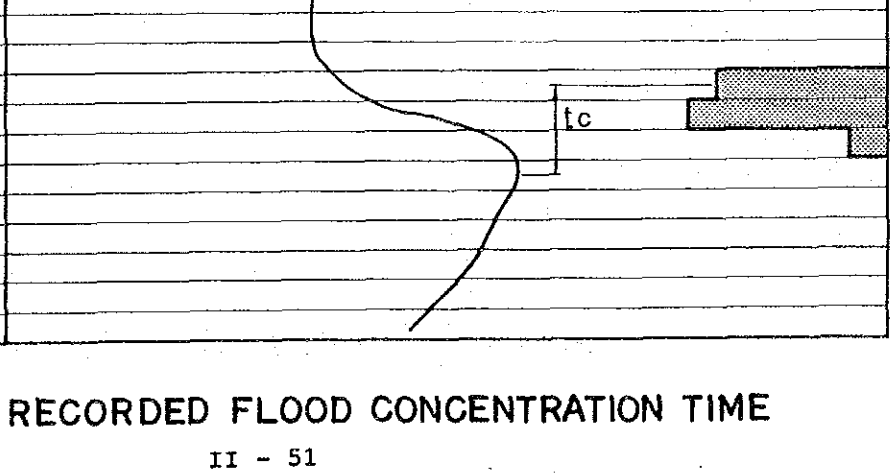


Fig. II.2.7 RECORDED FLOOD CONCENTRATION TIME

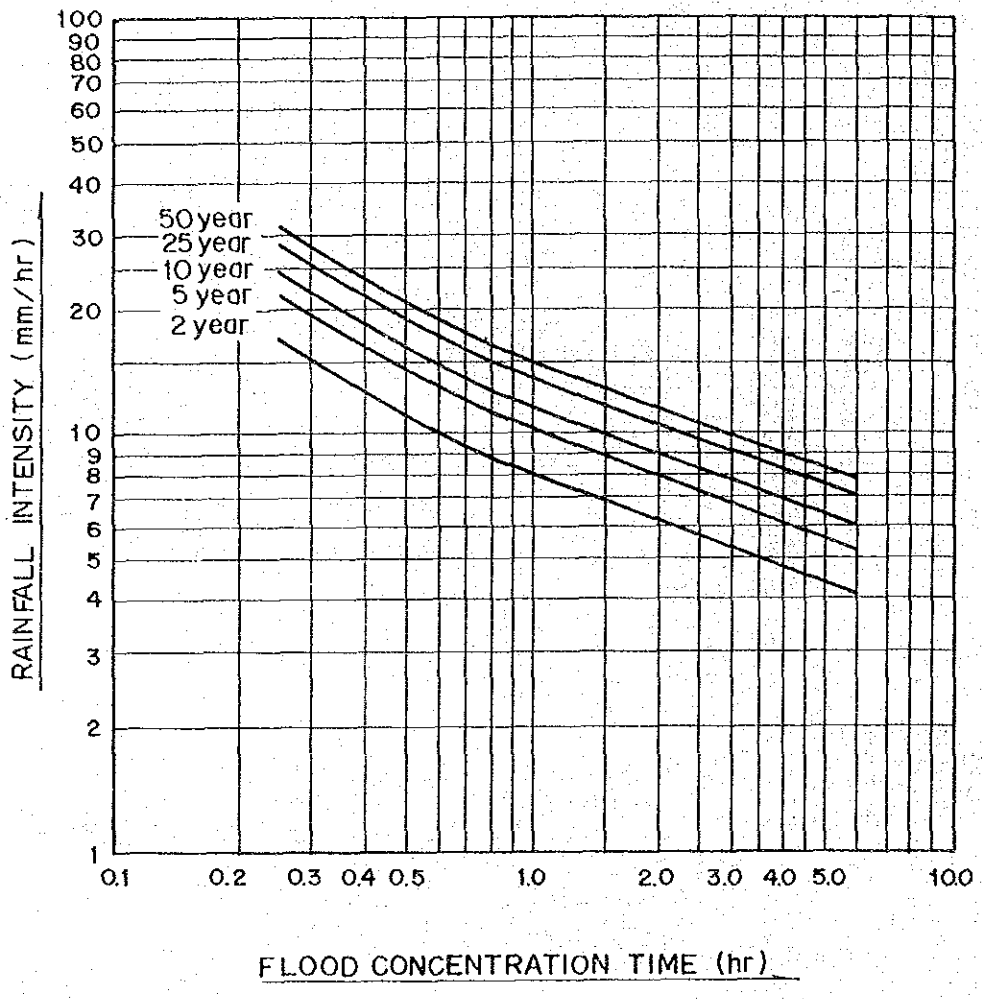


Fig. II. 2. 8 RAINFALL INTENSITY CURVE

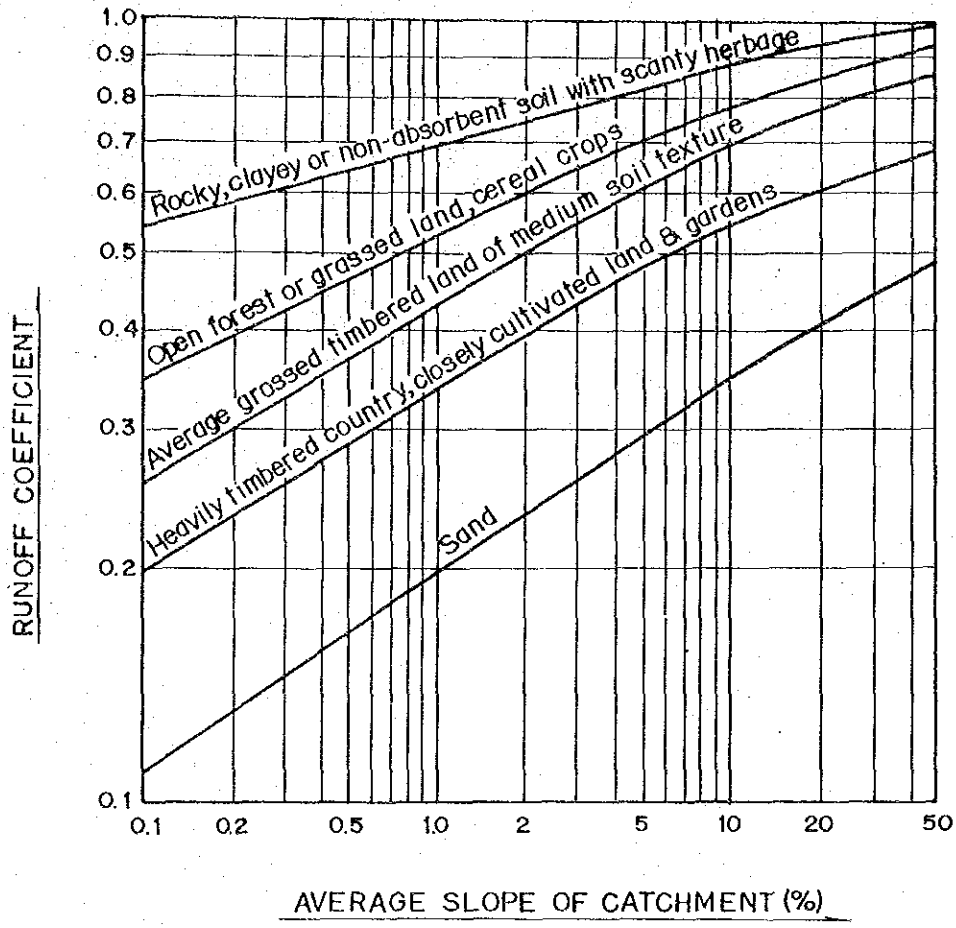


Fig.II.2.9 RUNOFF COEFFICIENT CURVE

ANNEX - III

LAND USE AND SOIL

LHUNTSHI AND MONGAR
INTEGRATED AGRICULTURAL DEVELOPMENT PROJECT

ANNEX-III LAND USE AND SOIL

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1. INTRODUCTION

The study area of the Lhuntshi and Mongar Integrated Agricultural Development Project is defined as the whole land in the Lhuntshi and Mongar Districts, which include the project areas of sixteen (16) existing or proposed irrigation schemes, which is defined in the "scope of Work". Out of the 16 project area, the Tangmachhu project area in the Lhuntshi and the Masangdaza project area (including Karbithang and Karibee project areas) in the Mongar District are selected for the model project area.

This report describes the present land use, distribution of the major soils, and the suitability of lands for agricultural development in the study area.

Through the field survey and the study, the following data and information were fully utilized for this study:

(1) Topographic maps scaled at 1:50,000 with interval of 40 m contours prepared by the Survey of India,

(2) Aerial photographs with the scale of 1:33,000 to 1:40,000 taken in 1978,

(3) Satellite imagery data of the Landsat V as mentioned in the report,

(4) Forestry Development in Bhutan (Report on remote sensing land use and vegetation mapping) prepared by FAO/UNDP in 1983, and

(5) Report on Soil and Land Capability Survey, Tashigang and Mongar Area Development Project prepared by FAO in July 1983.

2. PRESENT LAND USE

2.1 Past Studies and Statistics

The Department of Forestry carried out the land use survey using satellite imagery in cooperation with FAO from 1980 to 1983, and prepared the land use and vegetation map of Bhutan on a 1:250,000 scale. This survey covered 40,250 km^2 or 87% of the whole county. Data was compiled at district and river basin level.

According to this land use survey, 4,820 km^2 (2,900 km^2 or 85% of the Lhuntshi district and 1,920 km^2 or 87% of the Mongar Districts) of the study area was surveyed. The area by the land use category are shown in Table III.2.1. Out of the area surveyed in the both Districts, 8% was the agricultural land which included irrigated land, rainfed land and shifting cultivation. 74% of the area was forest and 18% was other land use such as exposed or rocky area, perpetual snow, etc. as summarized as followed.

(Unit : 1,000 ha)

	Agricultural Land	Forest Land	Other Land	Area Surveyed	Area Unsurveyed	Total Area
Lhuntshi	18.3	189.5	82.2	290.0	49.0	340.0
(%)	(6)	(66)	(28)	(100)		
Mongar	20.5	165.5	6.0	192.0	28.0	220.0
(%)	(10)	(86)	(4)	(100)		
Total	38.8	355.0	88.2	482.0	77.0	560.0
(%)	(8)	(74)	(18)	(100)		
Bhutan	355.9	2,839.9	829.0	4,025.0	625.0	4,650.0
(%)	(9)	(70)	(21)	(100)		

Source : Statistical Yearbook of Bhutan, 1987.

The Department of Agriculture (DOA) is estimating agricultural land use in the country every year by collecting data through the District offices. Agricultural land in Bhutan is generally divided in to five categories such as wet land, dry land, tsheri/pangshing land, kitchen garden and orchard/plantation. Wet land is irrigated or available for water and paddy is usually cropped by terracing and bunding. Dry land is permanent field for rainfed crops, and is usually sloping and not terraced. Tsheri or pangshing land is under shifting cultivation. Kitchen garden is the field for home consumption such as vegetables and root crops. Orchard and plantation includes the land growing perennial crops and fruits.

According to DOA, 7,900 ha or 1.4% of the study area were cultivated, and 21% of cultivated area was irrigated in 1984 as follows:

(Unit : ha)

	Wet Land	Dry Land	Tsheri Pangshing	Kitchen Garden	Orchard & Plantation	Total Area
Lhuntshi	1,200	1,600	700	100	-	3,500
Mongar	500	2,900	900	100	-	4,400
Total	1,700	4,500	1,600	200	-	7,900

Source : Statistical Yearbook of Bhutan, 1987.

Agricultural land use in the study area in 1985 is surveyed base on the statistical data of the District offices. 9,610 ha or 1.7% of the study area is cultivated, and around 14% of the cultivated land were irrigated as shown in the following table:

(Unit : ha)

	Wet Land	Dry Land	Tsheri Land	Kitchen Garden	Horti-culture	Total Area	Grazing Land
Lhuntshi	840	1,940	760	80	20	3,640	6,300
Mongar	530	2,900	2,450	40	50	5,970	6,060
Total	1,370	4,840	3,210	120	70	9,610	12,360

Source : District Offices.

Above land use data show considerable differences, because data sources, periods of data obtained and their measuring level are different. While land use data by DOA and the District offices are based on the net cropping area which is actually cultivated, the data obtained from the Landsat imageries are based on the gross area. The Landsat imagery can not identify the small segments less than about 0.5 ha. Considering that the cultivated land is sporadically distributed and mixed with the different land use, the Landsat imagery tends to count lager area into the dominate land use of forestry.

In addition to these differences, the statistical data of DOA and the District offices are less reliable because these data are estimated on the basis of the assumption of the block level. It is considered that the statistical data estimates is too small.

2.2 Present Land Use of the Study Area

The present land use in the study area is estimated by applying the remote sensing using the satellite imagery to cover the wide area of the Lhuntshi and Mongar Districts.

The contiguous two scenes (Path:137/Row:41 and Path:138/Row:41) of the satellite imagery taken by the Landsat V are used for estimation of the land use.

These scenes cover the study area and the surrounded area, and 1:50,000 scaled maps were used for control maps. Because the control maps of the northern part of the study area were not available, the measurement of the areas in each land use category was limited within the area available for the control maps of 27°00'N to 27°45'N in latitude and 90°15'E to 91°30'E in longitude. The area measured by land use categories covers 54% (3,038 km^2) of the study area, which consists of 33% (1,105 km^2) of Lhuntshi Districts and 88% (1,933 km^2) of the Mongar Districts.

The Landsat data taken in two different periods (January 17, 1986 for dry season and May 9, 1985 for rainy season) were processing and applied for analyses on land use to get higher accuracy.

The data were preliminarily processed to the false color imagery, and were checked through the field survey. After the field checking, the data were finally analyzed and the land use of the study area are classified into 5 categories, namely, paddy field, upland/pasture, bare land, sparse forest and dense forest.

The results of analysis are shown on Fig.III.2.1, and the estimated land use is summarized as follows;

(unit : ha)

Item	Lhuntshi		Mongar		Total	
Paddy field	1,700	(1.5%)	1,300	(0.7%)	3,000	(1.0%)
Upland and pasture	12,100	(11.0%)	22,200	(11.5%)	34,300	(11.3%)
Bare land	1,300	(1.2%)	3,500	(1.8%)	4,800	(1.6%)
Sparse forest	11,400	(10.3%)	18,800	(9.7%)	30,200	(9.9%)
Dense forest	84,000	(76.0%)	147,500	(76.5%)	231,500	(76.2%)
Total	110,500	(100.0%)	193,300	(100.0%)	303,800	(100.0%)
Study area	340,000		220,000		560,000	

The estimated area by land use categories is the gross area of each land use, and includes small segments of other land uses. This means that the net area of agricultural land is less than the estimated area.

In the above estimation, the paddy field would be classified into wet land, and the upland and pasture would include dry land, tsheri/pangshing land, and grazing pasture of the land use categories in Bhutan. Based on the above results, the present land use were estimated by the Bhutanese land use categories as shown Table III.2.2, and summarized as follows;

Item	Lhuntshi (ha)	Mongar (ha)	Total (ha)
Wet land	1,700 (30.9%)	1,300 (11.0%)	8,200 (47.4%)
Dry land	2,600 (47.3%)	5,600 (47.6%)	8,200 (47.4%)
Tsheri land	1,000 (18.2%)	4,700 (39.8%)	5,700 (32.9%)
Kitchen garden	100 (1.8%)	100 (0.8%)	200 (1.2%)
Horticulture	100 (1.8%)	100 (0.8%)	200 (1.2%)
Total	5,500 (100%)	11,800 (100%)	17,300 (100%)

Although the areas by land use categories are estimated on the basis of the gross area of each land use item, the actual cultivated area of wet and dry land is larger than the statistical data of DOA and the District offices.

2.3 Present Land Use of the Project Areas

For the 16 project areas in the study area, agricultural land use is surveyed by means of interviewing extension workers and supervisors. The results are summarized as follows:

(unit : ha)

Project Area	Wet Land	Dry Land	Tsheri Land	Others Land	Total. Land
Lhuntshi District					
1. Pang khar	6	19	9	1	35
2. Gangzoor	16	18	4	1	39
3. Tangmachhu	184	102	98	4	388
4. Minji	116	42	20	28	206
5. Menjibi	12	7	3	1	23
6. Kupinesa	16	38	32	3	89
7. Wambur	43	81	16	0	140
Sub-total	393	307	182	38	920
Mongar District					
8. Chali	54	100	50	0	204
9. Karbithang	10	0	0	0	10
10. Kribee	0	22	15	0	37
11. Masangdaza	16	39	0	0	55
12. Pangsibi	0	18	5	0	23
13. Gyelposhing	38	4	0	0	42
14. Kalapang	0.4	9	5	0	14.4
15. Yadi	29	77	30	0	136
16. Chaskhar	46	186	73	0	305
Sub-total	193.4	455	178	0	826.4
Grand total	586.4	762	360	38	1,746.4

Based on the interpretation of aerial photographs and the field survey, land use of the fifteen project areas is classified into four categories i.e. forest land, grass land (including shrub land, tsheri land, and pangshing land), dry land or upland, and paddy field. Land

use maps for each project area are shown in the Profiles of the Project Area in Annex X.

2.4 Present Land Use of the Model Project Area

Through the field survey and the aerial photo-interpretation, the present land use of the model project areas are classified into four categories, namely paddy field, upland or dry land, grass land including tsheri land, and forest. The land use maps with the scale of 1:25,000 are shown on Fig. III.2.2.

Such agricultural lands as wet/dry land and other land use are mixed with each other in the small parcels, and it is impossible to illustrate each land use on the maps. In this sense, the present land use maps show the general distribution or outline of each land use.

In the Tangmachhu model project area, the gross wet land is 445 ha, consists of 391 ha in Tangmachhu and 54 ha in Nebi. This gross area of wet land includes small segments of dry land, grass land, road, foot pass, residential area, kitchen garden, etc, and dose not includes wet land located along the Tangmachhu canal in a small scale. The gross dry land accounted at 74 ha, including grass land and other land same as wet land.

In the Masangdaza model project area, the gross wet land is 44 ha, composed of 2 ha in Bongdima, 22 ha in Masangdaza and 19 ha in Karbithang. Same as the Tangmachhu area, the gross wet land includes other land use categories. The gross area of dry, tsheri and grass lands are 106 ha, consists of 8 ha in Bongdima, 56 ha in Masangdaza and 32 ha in Karibee.

3. Soil

3.1 General

The major factors affecting soil formation in the study area are as follows:

(i) geographical condition, especially micro topography,

(ii) vegetation affected by the climatic condition such as monsoon which provides seasonal rainfall and altitude varied from 300 m to over 4,000 m, and

(iii) parent material such micaceous schists and pegmatite, and

(iv) activities by the habitants.

The geographical condition of the study area is undulating and hilly. The deep and big canyon is running north to south along the Kuri chu. Many tributaries have been dissecting and incising the slopes of the canyon laterally for the long period. Therefore, the slopes are generally very steep and relieves of ground surface are intricate.

Flat lands are sporadically located on the alluvial terraces in small scale at the bottom of the deep valley along the Kuri chu. Gently or moderately sloping area is generally situated at the middle or upper part of the canyon, which might be old river head in ancient period or might be formed by the land slide.

Climatic condition in the study area is generally governed by the monsoon, which provides the periodical rainy season in summer time and dry seasons in winter. However, the altitudes of the study area varies from 300 m in the bottom of the valley to over 4,000 m in the higher mountains, vegetation also varies with the altitudes. Usually, vegetation in the lower altitude is classified into sub-tropical, in the middle altitude area is temperate, and in the higher altitude is alpine. Based on these vegetation zone, soils have been developing in different profiles.

Dominant rocks as parent material in the study area are micaceous shists, migmatites and granitgnesses, and these rocks have high content of mica or biotite. These rocks have been weathered to soils for long periods. Many small particles of unweathered mica and biotite are generally found in the soils. Accordingly, potassium contents of soil is high.

Main industry of the study area is agriculture, and arable land is sporadically situated in a small scale among the hilly areas.

Local habitants have been cultivating steep slopes and have been grazing cattle in the hilly area. Shifting cultivation by denuding the forest has been carried out in the long period. Accordingly, some areas area suffered from soil erosion. Soils in the such eroded area have shallow surface soil and soil profile has developed weakly.

The field survey in parallel with the land use survey was carried out mainly in the 16 project areas. Soil profile survey was also conducted and soil pits were dug to a depth of about one meter or upto bedrock or gravel layer. Each soil profile was observed in accordance with the standards of "Guideline of Soil Profile Description" published by FAO. Furthermore, test boring survey was additionally practiced to estimate distribution of soils.

3.2 Soils in the Study Area

Through the field reconnaissance in the study area as well as soil profile observation and auger boring survey in the project areas, soils in the study area are generally classified into seven soil units according to the FAO/UNESCO soil classification system, i.e. Phaeozems, Cambisols, Acrisols, Gleysols, Arenosols, Regosols and Lithosols.

Phaeozems occur at steep slopes in high altitude over 2,000 m, are not found in the project areas. Vegetation of these soils are forest or grass land. These soils have strongly structured A horizons porous B horizon.

Cambisols are generally extends over middle to low altitude area, which formed by the old land slides. These soils are found on the gentle to steep slopes. These soils are usually cultivated where slopes are not steep. Surface layers of these soils have been supplied from upper slopes and have been eroded to down slopes, therefore surface horizons are developed weakly and texture is medium to coarse like clay loam. Soil color is yellow to brown. The land of this soil unit has medium potential for cultivation, and there is no serious limitation except steepness.

Acrisols extend over the upper slopes of the cultivated land as well as glass land. Soil layer is rather deep and texture is fine. These soils are presently used for dry land or tsheri land cultivation or grazing forest.

Gleysols are formed in the middle of the slopes where spring water is annually available and the slopes are gentle to medium such as in Tangmachhu, part of Pang Khar and Masangdaza. In such cases the surface soil texture is fine, and the content of organic matter is relatively high. Hydromorphic feature is observed in the B horizon which soil color is grey. These soils are presently used as the paddy

field, and have high potential for agricultural production after improvement of drainage.

Arenosols can be found on the alluvial terraces. These soils are derived from recent alluvial materials, have coarse textured soil profile, and contain much gravels and stones. Usually, permeability is high and content of nutrients for crops is low. Potential of these soil is not high because of high permeability, high gravel content and low fertility, therefore, high agricultural production can not be expect in these soils.

Regosols and Lithosols extend over the steep and/or south slopes on the hard and weathered bed rocks, where vegetation is scarce. These soils are easy to be suffered from serious soil erosion. Lithosols has shallow and gravely surface layer usually less than 10 cm, and almost no B horizon developed between A horizon and C horizon. Regosols has weakly developed surface horizon and its depth is relatively deeper than that of Lithosols, however, this soil is gravely. Because their surface horizon is thin, stony and with poor chemical properties for crops, these soils have low potential for agricultural production, and it should be kept for natural vegetation to prevent soil erosion for land conservation.

Soils in the project areas were surveyed through soil profile observation of the typical land use in each project area. 23 profiles were observed in the project ares in total, and these descriptions and soils in each project area are shown in the profiles of the project areas in the Annex X.

3.3 Soils in the Model Project Areas

Additional survey was conducted in the model project areas through soil profile survey. 8 profiles in the Masangdaza area and 5 profiles in the Tangmachhu area were observed in total. Major soils of the cultivated land in the model project areas are Gleysols, Cambisols, Acrisols and Arenosols.

Gleysols are found in the Tangmachhu area, and are situated on the almost flat land which are usually utilized as paddy field. In these area, ground water table is high and spring water is annually available. Usually, lower part of the profile has black colored horizon, which organic matter content is high. This horizon was formerly surface of the marsh land and was buried by the land slide. While these soils are good for cultivation, especially for paddy, soil moisture content is too high to grow upland crops.

Acrisols are mainly found on the upper part of the Tangmachhu area almost more than 1,600 m in altitude, and are mainly utilized as dry land. Surface soil has dark reddish brown color. Subsurface soil

is light reddish brown. Texture of soil is silty loam to loamy clay. Structure is moderate blocky to angular blocky in fine to medium size. Soil depth is rather deep, sometimes over 1 m. Sometimes stones and cobs are contained. These soil has high erodability. Accordingly, Acrisols is not high in potential for agricultural production, but can be cultivated by terracing to prevent soil erosion and by proper management such removing stones and manuring.

Cambisols extend over the middle to lower part of the Tangmachhu area and most area of the Masangdaza area, and are utilized as paddy field, dry land, tsheri land or grazing grass land depending upon the steepness of slopes. Soil color of this soil is dark yellowish brown in top soil to reddish brown in subsurface soil. Texture is clay loam through the profile. These soils have fine to medium and moderate blocky structure, and sometimes contain stones. Lower part more than 1 m depth sometimes shows the black colored horizon, which was old surface and buried by the slided soils. Although agricultural potential of these soils are not high, some areas have been cultivated as paddy fields for many years and produce ordinary yields through proper management.

Regosols are found in the part of Bongdima village in the Masangdaza area. Presently part of these soils are utilized as dry land, but their productivity is very low. Texture is coarse and top soil is shallow. Content of stones and gravels are very high. These soils have almost no potential for cultivation.