REPORT OF JAPAN DISASTER RELIEF TEAM (EXPERT TEAM) ON HEAVY RAINFALL AND FLOODS IN NEPAL

OCTOBER, 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

On August 24, 1993, following a request from the Government of Nepal, the Government of Japan decided to provide emergency disaster relief services for the floods damage which occurred in the Southern part of Central Nepal from July 18, 1993.

Based upon this decision, the Japan International Cooperation Agency (JICA) immediately organized and dispatched a Japan Disaster Relief Team (expert team) to Nepal from August 25 to September 7. The team was headed by Hiroyuki Yoshimatsu, Head of Landslide Division, Erosion Control Department, Public Works Research Institute, Ministry of Construction. The expert team carried out a field survey and provided technical advice, based on a Japanese experience, regarding emergency measures and rehabilitation, and suggestions for the prevention of future disasters.

This report is a summary of the expert team's field activities and the recommendations they gave on returning to Japan.

I hope that this report will serve to assist Nepal in its future plans for disaster prevention and rehabilitation and that it will also contribute to the promotion of friendly relations between Nepal and Japan.

Finally, I wish to take this opportunity to express my deepest appreciation for the cooperation and assistance given by all concerned with the disaster relief activities.

October 1993

Daiji Ozawa, Vice President
Japan International Cooperation Agency

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1. Introduction

Between the nineteenth and the twenty-first of July 1993, continuous heavy rain totaling 830 millimeters (July 19 8:00 AM to July 22 8:00 AM, Nibuwatar) fell southern part area of Central Nepal. Rivers originating in this area flooded, causing numerous debris flows and landslides (including slope failures) in mountainous regions. This rainfall is equivalent to one third of the area's normal annual precipitation, which ranges from 2,000 to 2,500 millimeters. The area affected by the disaster extended to 44 districts in Nepal, and its damaged area reached 47,327 hectares. In five of these 44 districts, namely Chitwan, Makwanpur, Sindhuli, Rautahat, and Sarlahi, the disaster was particularly severe.

Table 1.1 presents a summary of the disaster caused by the heavy rainfall of July 19 to July 21. As many as 201 persons are still missing as of September 16. Enormous damage was done to road bridges, which were washed away or destroyed by flood waters. This is seriously obstructing transportation of goods to Kathmandu. Damage to electric power generating facilities by debris flows and landslides is severe affecting the country's economic activity. The flooding also washed away puddy fields and damaged irrigation facilities in the low land agriculture zone on the Terai Plain, creating severe food supply problems in this nation where 90% of the people work in agriculture. The tentative damage by the July Flood is summarized in the Table 1.1.

Tab. 1.1 Summary of the Disaster Caused by Heavy Rainfall Between July 19 – 22, 1993 (September 16, 1993, by the Central Disaster Relief Committee)

Human Loss (persons)	
Dead	1,259
Missing approximately	201
Buildings	
Totally Destroyed	18,322
Partially Destroyed	20,721
Public Buildings	452
Land Washed Away (hectares)	43,330
Livestock (head)	25,626
Roads Washed Out (km)	366.89
Bridges Destroyed	213
Dams Destroyed	34
Irrigation Channels Destroyed	620
Total Loss (Rupees)	4,875,278,484.9

On August 13, the Government of Nepal requested that a team of specialists on flooding, irrigation, debris flow and landslides be dispatched to advise with in regard to technical matters for rehabilitation of damages in Nepal. Based upon the Japanese Law Concerning the Dispatch of International Emergency Relief Teams, this international emergency relief team was dispatched.

Table 2.1 Loss of Lives & Property (Final Figure) as Reported by Central Disaster Relief Committee on 16 September 1993

Date: 09/16/93 Time: 16:24:02

S No.	District	Affected HH	Pop	Deaths	Missing	Injured	Destroyed Complete	House Partly	Land Area	Loss Unit	Crop Area	Loss Unit	Livestock Loss	Roads in Km	Bridge in No.	Dams	PMIS	Publ Bldg	Food Qty	Grain Loss Unit	Total Worth
1.	ARGHAKHANCHI	0	0	2	0	1	0	0	0		0.000		2	0.00	0	0	0	0	0.000		669500.00
2.	BAGLUNG	12	0	1	0	0	20	5	19	HECTAR	0.000		0	0.00	0	0	10	0	0.000		0.00
3.	BANKE	0	1400	1	0	0	73	39	0		0.000		0	0.00	0	0	0	0	0.000		0.00
4.	BARA	557	0	2	0	0	63	41	40		549.000	BIGHA	0	6.00	0	0	0	0	0.000		21592062.90
5.	CHITWAN	5293	34943	22	13	71	2200	613	1522		0.000		1012	0.60	2	2	0	0	0.000		0.00
6.	DHADNING	1113	23628	24	0	16	525	394	1075	"	2917.000		321	1.29	16	0	1	38	2917.000	TON	17310000.00
7.	DHANUSHA	3225	22046	0	0	0	482	1567	34		9391.000	HECT	18	10.00	5	9	74	5	100.000	TON	159615100.00
8.	DOLAKHA	0	0	0	0	0	0	30	1	"	0.000		0	0.00	0	0	0	0	0.000		0.00
9.	DOTI	0	0	1+8:9	1	0	0	0	0	"	0.000		22	0.00	0+1*	0	0	0	0.000		0.00
10.	GORAKHA	28	0	0	0	0	21	0	12	"	38.000		0	0.00	9	0	0	1	0.000		2394000.00
11.	GULMI	3	0	0	0	0	3	0	0	"	0.000		5	0.00	0	0	0	0	0.000		120500.00
12.	JHAPA	0	0	0	0	0	18	11	1	"	2.600		0	0.00	0	0	0	0	0.000		0.00
13.	KALALI	0	0	2	0	0	0	0	106	"	0.000		0	0.00	0	0	0	0	0.000		0.00
14.	KALIKOT	0	0	0	0	0	1	0	0		0.000		0	0.00	0	0	0	0	0.000		0.00
15.	KASKI	0	0	1	0	0	0	0	0		0.000		0	0.00	0	0	0	0	0.000		0.00
16.	KATHMANDU	10	0	2	0	3	8	0	3	"	0.000		0	0.00	1	0	0	0	0.000		0.00
17.	KAVRE	2958	10642	20	0	3	914	92	1030	"	0.000		159	0.00	0	0	0	0	0.000		86274750.00
18.	KHOTANG	0	0	1	3	5	30	0	0	"	0.000		100	0.00	0	0	4	14	0.000		13932086.00
19.	LALITPUR	0	0	6	0	7	57	51	135	"	0.000		0	0.00	2	0	0	0	0.000		0.00
20.	LAMJUNG	0	0	0	0	0	1	5	0	"	512.000	MURI	0	0.00	1	0	1	0	0.000		0.00
21.	MAHOTTARI	13	0	8	2	3	0	0	0	"	0.000		0	0.00	12	0	0	0	0.000		0.00
22.	MAKKANPUR	14748	101482	242	7	39	1732	1879	4656	"	85460.000	"	665	7.92	16	1	251	118	0.000		1198648381.00
23.	MORANG	0	0	0	0	0	0	0	5	"	0.000		0	0.00	0	0	0	0	0.000		0.00
24.	MUSTANG	0	0	0	2	0	0	0	0		0.000		0	0.00	0	0	0	0	0.000		0.00
25.	NAWALPARASI	0	22800	0	0	0	300	500	0		0.000		0	0.00	0	0	0	0	0.000		0.00
26.	OKHALDHUNGA	76	0	0	0	0	250	315	550		491.000	"	104	0.00	1	0	0	2	4956.000		105385653.00
27.	PALPA	0	0	9	0	0	1	8	0		0.000		9	0.00	0	0	1	1	0.000		150000.00
28.	PANCHTAR	1115	5575	22	0	0	13	93	176	"	4585974.000	RS	23	0.00	0	0	0	0	0.000		18717191.00
29.	PARSA	826	0	2	0	0	53	78	356	"	1300.000		104	4.88	5	0	1	5	36.000	TON	155916000.00
30.	PYUTHAN	41	0	0	0	0	0	0	0		0.000		0	0.00	0	0	8	0	0.000		556300.00
31.	RAMECHHAP	0	0	3	0	5	299	345	498	"	0.000		128	4.00	4	0	51	21	261.000	"	0.00
32.	RAUTAHAT	14644	89146	111	115	33	2003	3541	1366	"	7821.000	HECT	3211	40.00	13	0	1	37	31673.000	QTL	899680261.00
33.	RUPANDEHI	0	0	1	0	0	296	0	0		0.000		0	0.00	0	0	0	0	0.000		0.00
34.	SALYAN	0	0	4	0	0	1	0	0		0.000		0	0.00	0	0	0	0	0.000		53480.00
35.	SAPTAR	0	8109	0	0	0	48	0	0		0.000		0	0.00	0	0	0	0	0.000		0.00
36.	SARLAHI	15560	83265	687	56	0	7066	8494	25966	"	25966.000	"	17736	266.00	81	4	117	194	0.000		1118918500.00
37.	SINDHULI	11051	59142	52	0	23	1206	1314	4061	"	5145.000	BIGHA	1930	26.00	41	5	6	24	1186.000	TON	863497648.00
38.	SINDHUPALCHOK	59	374	0	0	0	3	13	14	"	0.000		0	0.00	0	0	0	0	0.000		0.00
39.	SIRAHA	1145	28806	0	0	0	523	292	1421	"	1227.000	"	20	0.00	0	2	0	2	87.000	BIGHA	38300657.00
40.	SOLKHUMBU	0	0	0	0	0	0	0	0		132000.000	RS	0	0.00	2	0	0	0	0.000		0.00
41.	TANAHU	0	0	2	0	0	3	0	5	"	0.000		0	0.20	1	11	0	0	0.000		0.00
42.	TAPLEJUNG	811	3184	29	0	10	74	1	110	"	0.000		3	0.00	0	0	46	0	0.000		17756395.00
43.	TERHTHUM	0	0	2	2	0	45	0	53	"	2238960.000	RS	54	0.00	1	0	48	0	5.670	TON	0.00
44.	UDAYPUR	318	1590	1	0	0	0	0	115		0.000		0	0.00	0	0	0	0	0.000		0.00
	GRAND TOTAL	73606	496334	1259	201	219	18322	20721	43330				25625	366.89	213	34	620	452	41221.670	TON	4875278484.90

* The Kathmandu Post News Data 09/24/93

2. The Rainfall and Conditions in the Disaster Area

The heavy rainfall from July 19 to July 22 was concentrated in the Kulekhani area centered on a point approximately 30 km south-west of Kathmandu in Central Nepal (Fig. 2.1). The rainfall pattern of this rainfall shows that there were, rather than one, two peak periods of rainfall. According to the observation records from Nibuwatar (Hazama Camp) in the Rapti River basin, the rainfall peaked between 17:00 and 18:00 on July 19, and between 20:00 and 21:00 on July 20, with 60 mm and 64 mm of rainfall in those two periods respectively (Fig. 2.2). At Tistung in the upstream area of the Kulekhani Khola, the rainfall peaked 21:00 to 22:00 on July 19, and 4:00 to 5:00 on July 20, when hourly precipitation of 65 mm and 50 mm were recorded respectively (Fig. 2.3). During the same time periods, it rained by 75 mm and 28 mm respectively at Simlang (Kulekhani Reservoir) (Fig. 2.4).

Fig. 2.5 (T. Hagen 1980) explains a mechanism of rainfall in Nepal. This rainfall pattern is influenced by meteorological conditions that year, but generally, at the end of May and beginning of June, the monsoon moves slowly from southern India to the Terai Plain in Nepal in the north, and in the Mahabharat Lekh (Middle Mountains) and the Himalayas, it causes severe thunderstorms under the influence of local ascending currents. It seems difficult to distinguish between these pre-monsoon phenomenon and the monsoon, but while the thunderstorms are characterized by south-east winds, the monsoon winds can be distinguished from these because they bring rain from the Bay of Bengal in the south-east. The monsoon begins earlier in southern Nepal than in northern Nepal, and it lasts longer and is more severe in eastern Nepal. In central Nepal, where this heavy rainfall occurred, the monsoon begins in early June and continues until the end of September. This period is generally not lengthened, and is marked by intermittent rainfall. The daily weather is marked by bright sunlight occurring for very short periods, thanks to breaks in the clouds, but it rains frequently at night.

Two characteristics of this heavy rainfall causing the present disaster are:

1) Little rain fell during the day, with the peak period of concentrated rainfall occurring at night.
2) The area of rainfall appears to have been concentrated in the Middle Mountains zone, and spread to the south-west.

For these reasons, it can be defined as a typical rainfall caused by the monsoon. A comparison of Fig. 2.1 with Fig. 2.6, which is an annual precipitation distribution chart of Nepal, shows that the continuous total precipitation that fell during this heavy rainfall equalled a little more than 1/3 of the annual precipitation in the area. Nepal is not equipped with a complete precipitation observation network, but a maximum daily precipitation of 540 millimeters was recorded near the Kulekhani Power Plant. Records show that the total daily rainfall for July 19 was 540 mm at Tistung in Makawanpur District, 334 mm at Simlang, and 418 mm at Borrow Pit. It is reported that one day's rainfall of 540 mm is the highest ever recorded in Nepal. (Fig. 2.7)

This district is a mountain basin zone typified by Kathmandu, which lies between the Middle Mountains, a range soaring to 2,500 m above seal level, and the High Mountain region to the north (Fig. 2.8). This concentrated rainfall caused many landslides and debris flows in the Middle Mountain region, where the geology is formed by granite, schist, and limestone. In the Siwalik

Mountains, where the average elevation is around 1,500 m, river water eroded the sides of river valleys. The floating trees and eroded sand and stone these rivers washed down to the Terai Plain, which lies at below an elevation of 300 m, caused flooding, destroying many wet fields.

The rain was particularly heavy in the Kulekhani drainage area, so that the disaster was concentrated in the districts of Makwanpur, Sinduli, Rautahat, and Sarlahi, which all lie in the river basin of the Bagmati River, which has its source in the Kulekhani area (Fig. 2.1). In these districts, the loss of human life caused by flooding was high. As we have already pointed out, the Middle Mountain Region where the rain was concentrated is composed of granite, schist, and limestone that was subjected to metamorphosed stress by tectonic movements caused by the formation of the Himalayas. The river valleys are, as a consequence, wild and sharp. The gradients of the slopes which form these mountains have asymmetrical slope gradients, having been influenced by the characteristics of stratum of opposite dip and by dip slope characteristics, which are characteristics of the bedding stratification structure of sedimentary rocks (Fig. 2.9, Ministry of Water Resources, 1987). In other words, the dip slopes feature gentle gradients, while the geological structural slopes of the stratum of opposite dip areas are steep. Consequently, the dip slopes are dominated by landslides which slide down the surfaces of the joints of the bedrock. Because of the scouring caused by the mountain streams that flow across the base of the stratum of opposite dip, these sections are dominated by the scouring of the sedimentary material in the bottom of the mountain streams and the collapse of the banks of the mountain streams.

The following are the factors which permitted these heavy rains to cause this large scale disaster described in Table 2.1.

1) The precipitation is considered to be the heaviest precipitation ever recorded, and the rainfall intensity was also very high.
2) Emergency measures to reduce the effects of the disaster were limited because the peak of the rainfall came at night when, it has been reported, evacuation and other measures were difficult to carry out.
3) The heavy rain fell in mountainous areas where the geology is characterized by severe weathering and metamorphosed stress of the granite, schist, etc., causing phenomenon such as debris flows which are extremely destructive, and flooding that carried off large quantities of soil, rock, and uprooted vegetation, and extensive erosion and sedimentation.

Sources

Toni Hagen, 1980: Nepal, Oxford & IHB Publishing Co. pp. 264

Ministry of Water Resources, 1987: Erosion and Sedimentation in the Nepal Himalayas

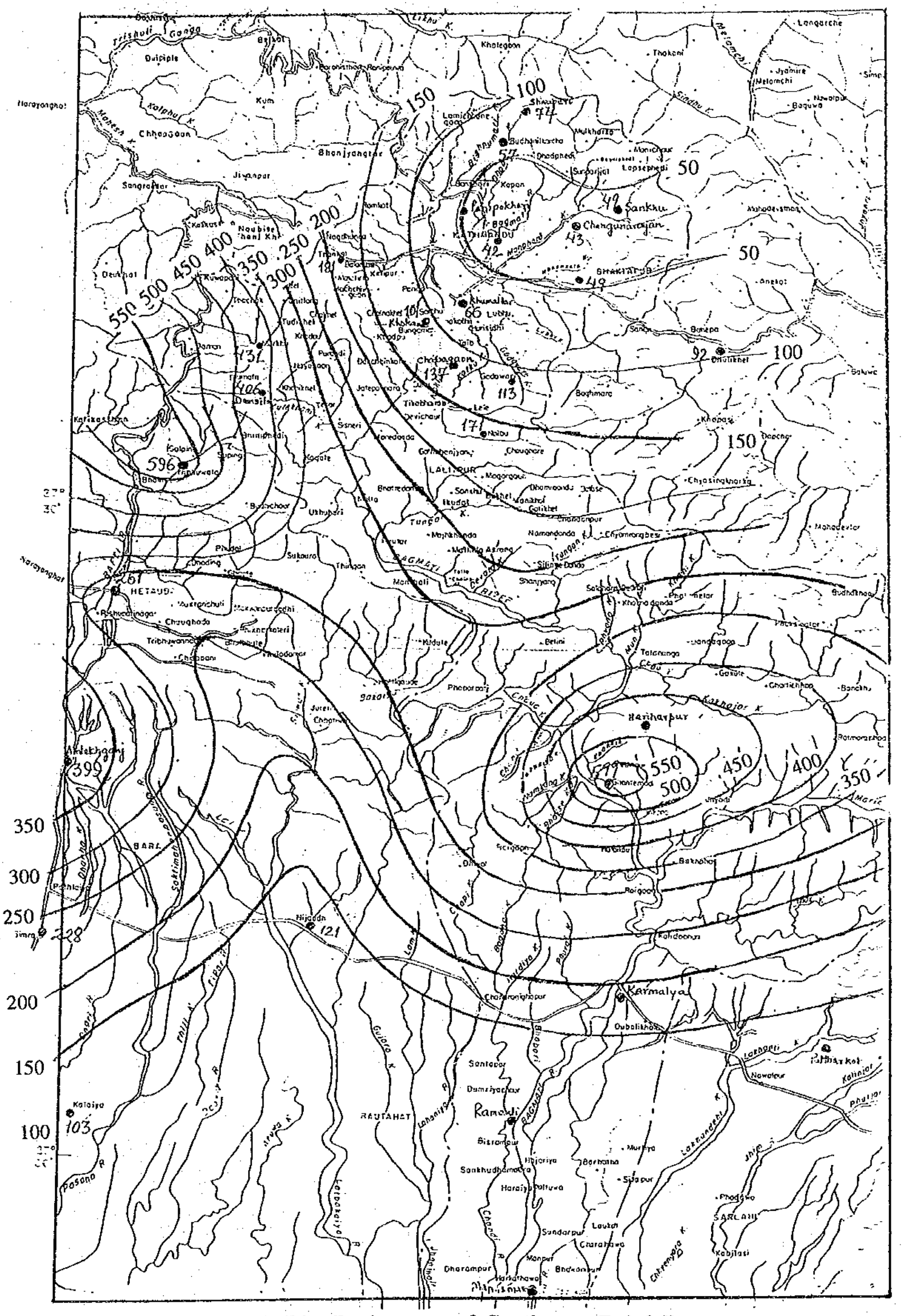


Fig. 2.1 Distribution map of Continuous Rainfall amount
(19/8:45) ~ (21/8:45), July, 1993, by Committee
for Case Study on Floods in Bagmati Basin)

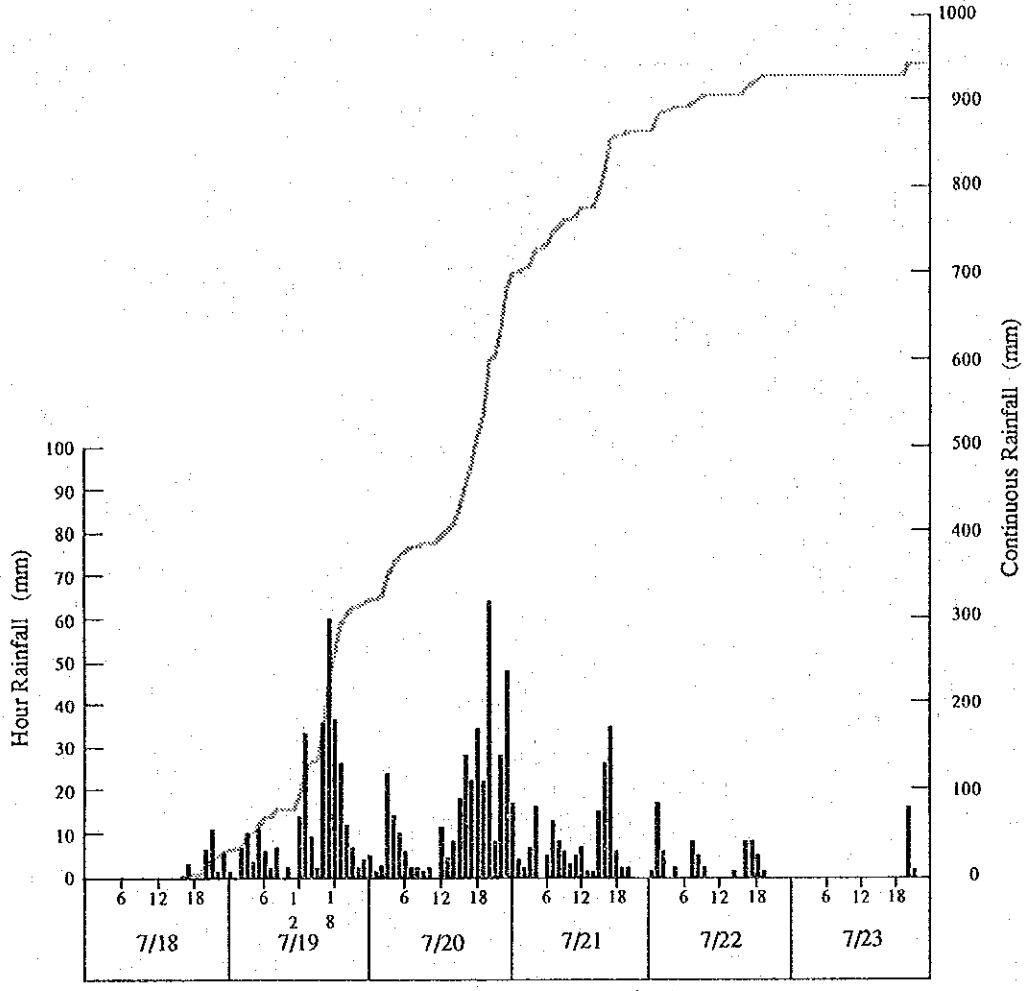


Fig. 2.2 Rainfall at Nibuwater (Hazama Camp) from 18 to 23 July 1993

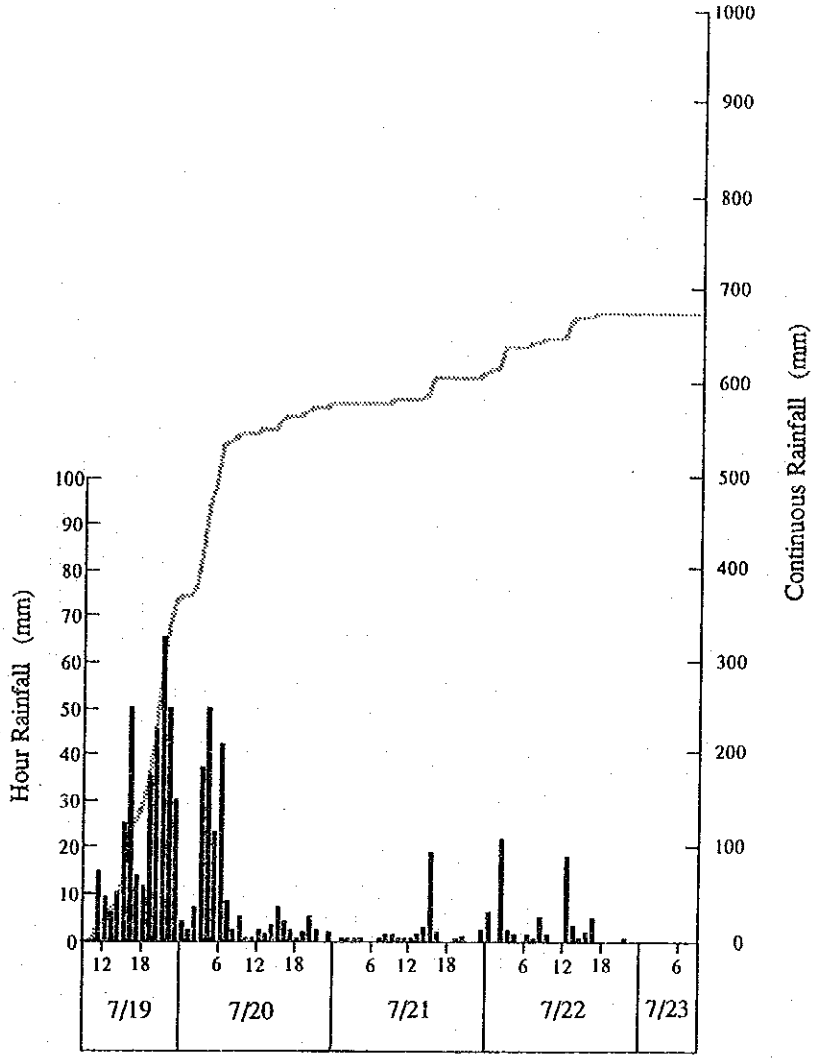


Fig. 2.3 Rainfall at Tistung (Upstream of Kulekhani Kohola) from 19 to 23 July 1993

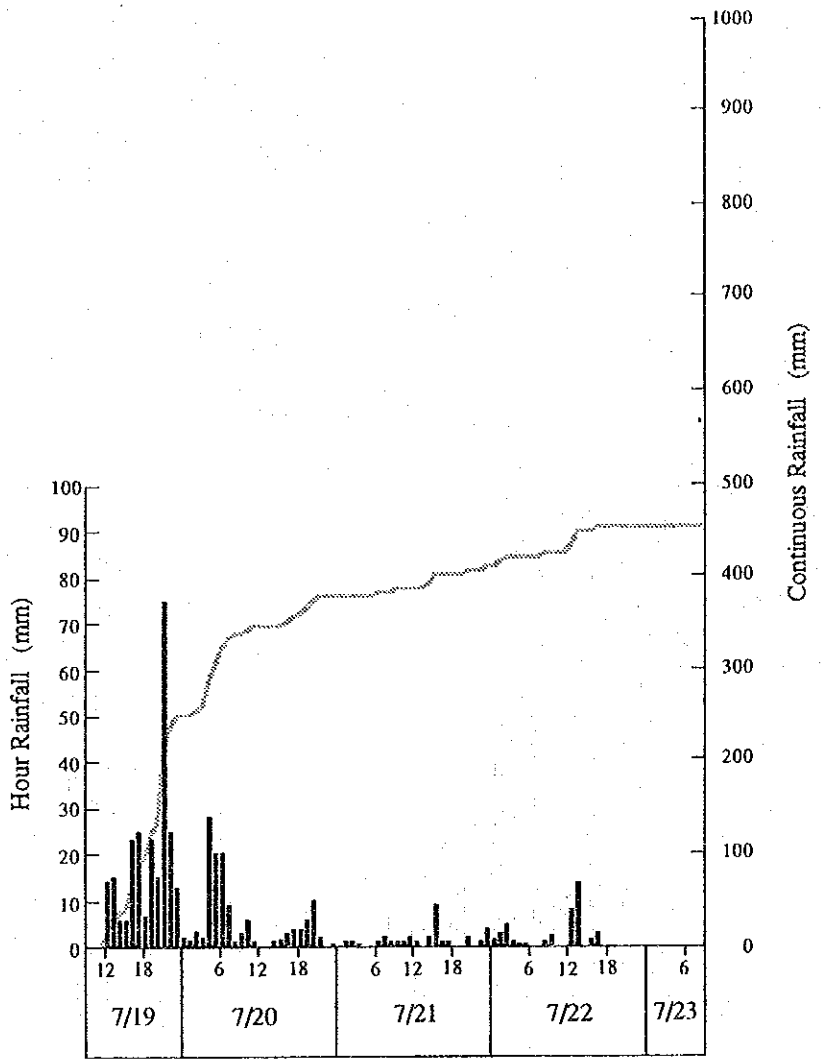


Fig. 2.4 Rainfall at Simlang (Beside the Kulekhani Reservoir) from 19 to 23 July 1993

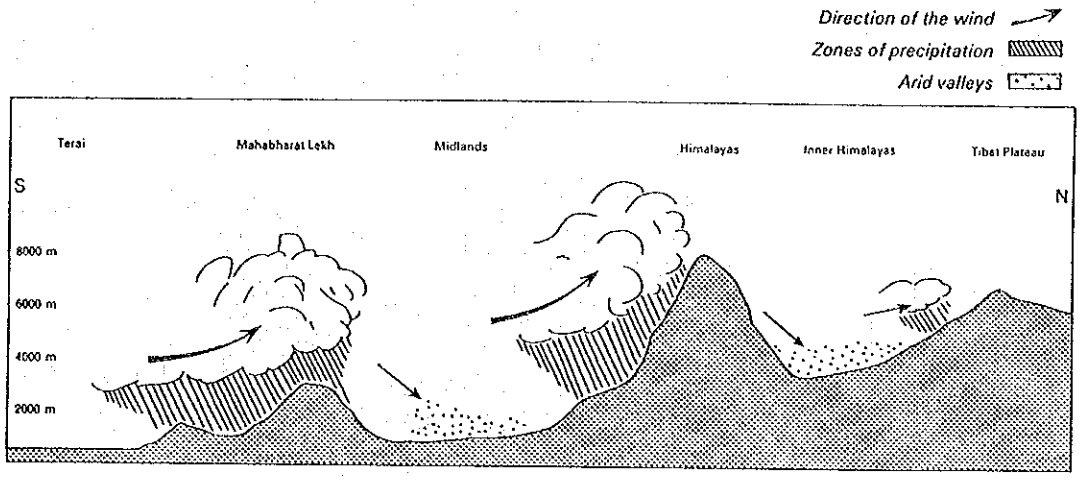


Fig. 2.5 The Principal Zones of Precipitation (Toni Hagen, 1980)

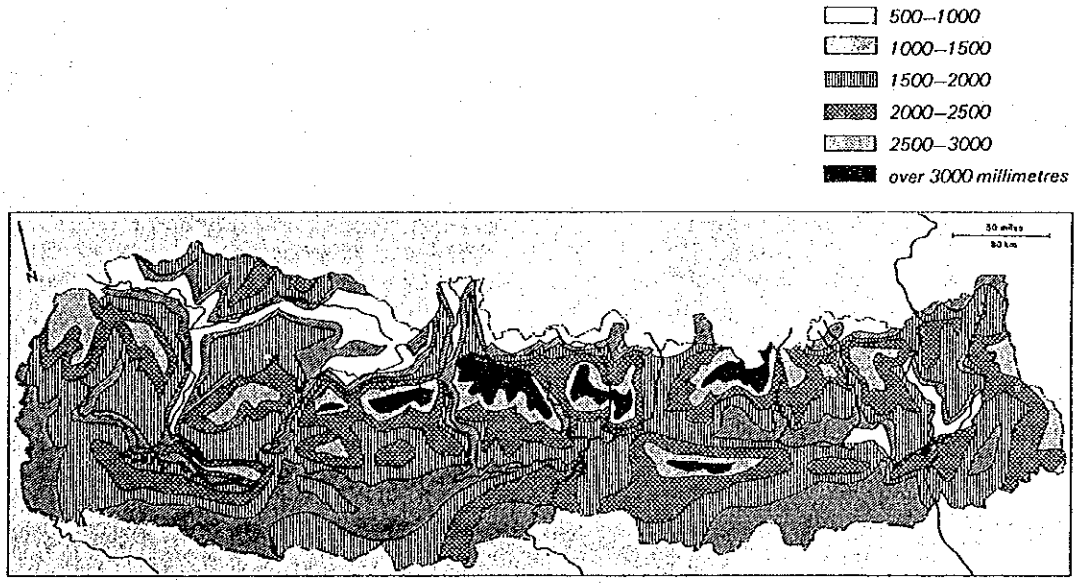


Fig. 2.6 Map of Annual Precipitation (Toni Hagen, 1980)

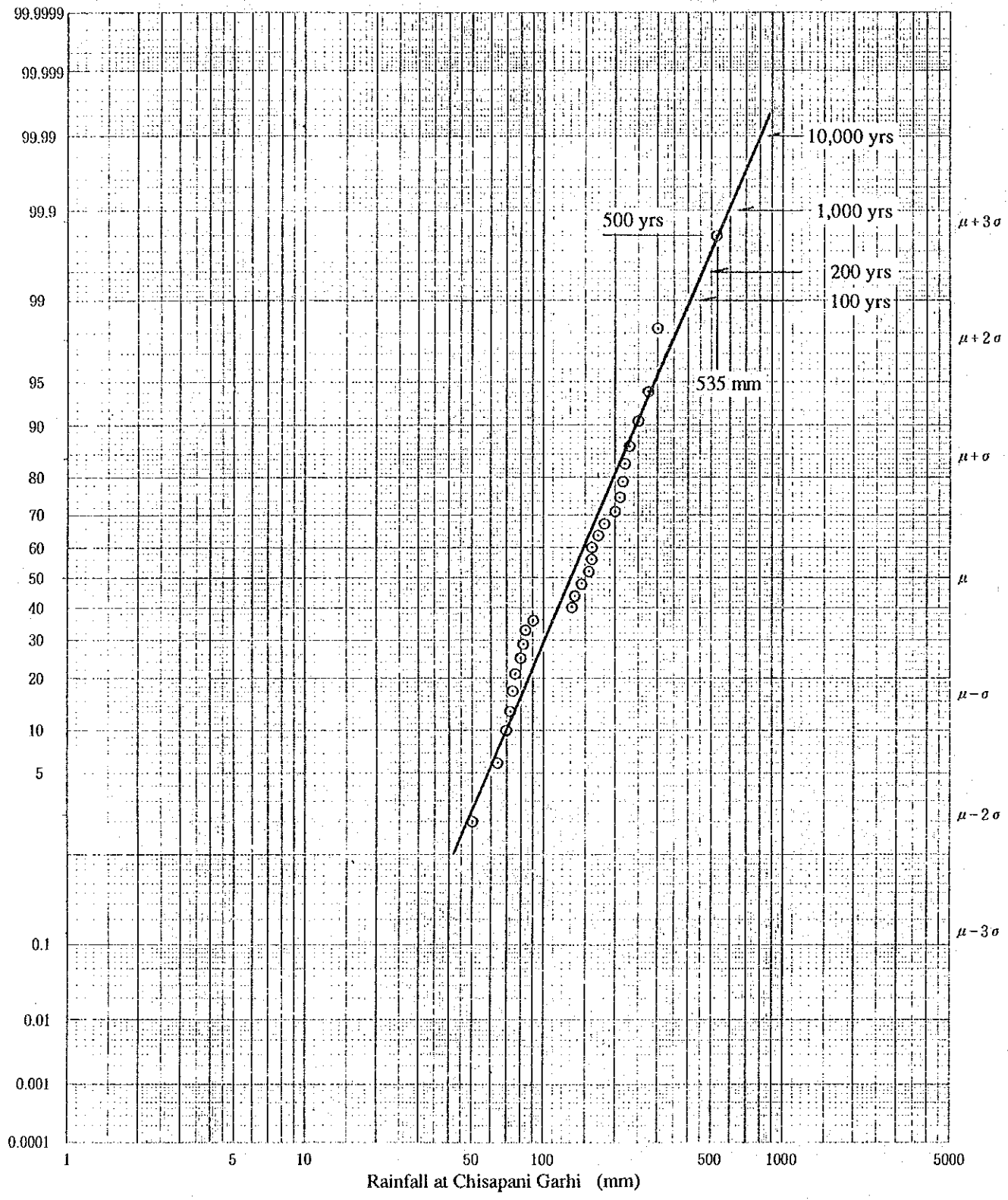


Fig. 2.7 Frequency Curve of 1-day Rainfalls at Chisapani Garhi

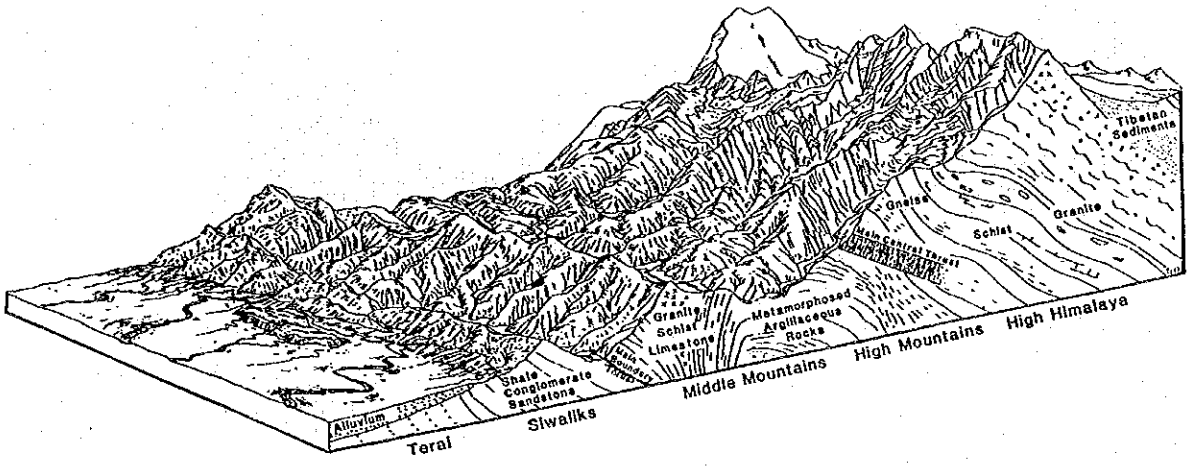
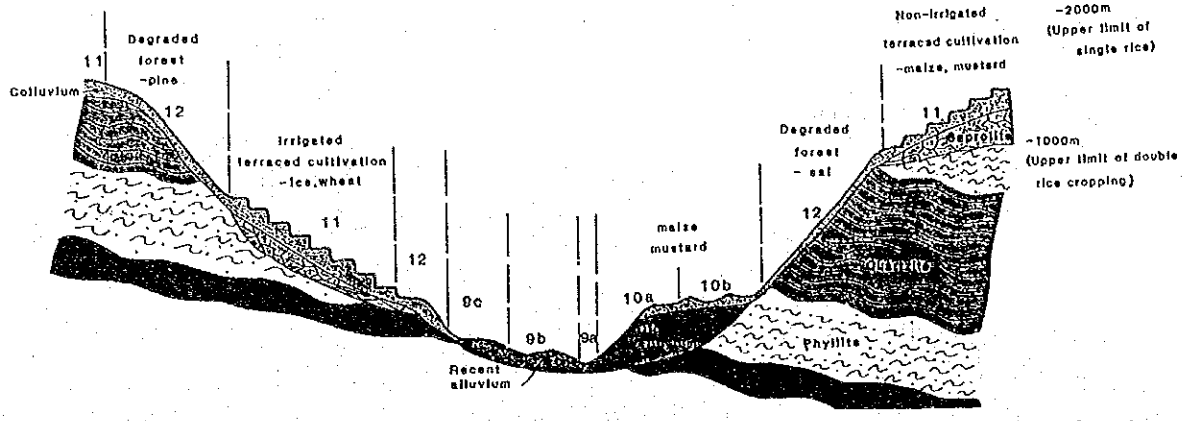


Fig. 2.8 The Physiographic Regions of Nepal (Ministry of Water Resources, 1987)



MIDDLE MOUNTAIN REGION **Precambrian to Eocene phyllites, quartzites, schists, limestones, and gneisses: Subtropical to Warm Temperate**

Land System	Land Form	Land Unit	Dominant Soils	Dominant Slopes	Dominant Texture	Seasonal Range of Depth to Water Table	Drainage
9	Alluvial Plains and Fans (depositional)	a) river channel b) alluvial plains c) alluvial fans	Paamments Ustorthents Ustifluvents Fluvaquents Ustochrepts	< 1°	Fragmental Sandy	0 - 2 m	variable
			Ustochrepts Haplustalts	1 - 5°	Loamy/Bouldery	1 - 15 m	well
10	Ancient Lake and River Terraces (Tars) (aroalonal)	a) non-dissected b) dissected	Typic & Rhodic Heplustalt Ustochrepts	0 - 5°	Loamy	> 2 m	well
11	Moderately to Steeply Sloping Mountainous Terrain		Typic, Rhodic, Udio, Anthropic Subgroups of Ustochrepts Dystrochreps Haplumbrepts	< 30°	Loamy Skeletal	50 cm to bedrock	moderately well to well
12	Steeply to Very Steeply Sloping Mountainous Terrain		Lithic Subgroups of it and Ustorthents	> 30°	Loamy Skeletal	50 cm to bedrock	well

Source: Kenting Earth Sciences Ltd. (1985)

Fig. 2.9 Land Systems in the Middle Mountain Region (Ministry, 1987)

3. Members of the Japan Disaster Relief Team and the Survey Schedule

3.1 Members

The names of the members of the J.D.R. team are shown on Table 3.1 on the next page.

Because it was impossible to completely clarify all details concerning the disaster caused by this rainfall, the circumstances surrounding the disaster were not clear. Therefore, the team set out to achieve the following three objectives.

1) Clarify the actual conditions of the disaster.
2) Offer proposals concerning emergency measures which ought to be taken without delay.
3) Offer proposals including a proposal for a survey in preparation for the establishment of future disaster protection measures and a disaster protection organization.

To conduct its on-site survey, the relief team used a helicopter to obtain an overview of the situation. Afterwards, they divided up into two squads to study major aspects of the disaster selected from among the many that had occurred. In other words, they looked into 'flooding and irrigation,' and 'landslides and debris flows.' The on-site survey was conducted with the cooperation of JICA experts and staff member of DPTC as follows.

(River Training and Irrigation Team)

Mr. Takashi INOUE	(JICA Expert on River Engineering)
Mr. Atsushi OKAMOTO	(JICA Expert on Sabo)
Mr. Shyam Prasad RIMAL	(Director of DPTC)
Mr. M. ISHIWATARI	(Embassy of Japan)
Mr. A.S. DHKAL	(DPTC)
Mr. D.P. ACHRYA	(DPTC)

(Debris flow and Landslide Team)

Mr. Hidetomi OI	(Chief Advisor of DPTC)
Mr. Kiyoshi AMAO	(JICA Expert on Landslide)
Mr. B. RAJKARNIKAR	(DPTC)
Mr. B. GYAWALI	(DPTC)

Tab. 3.1 Members List

1. Dr. Hiroyuki YOSHIMATSU Head Landslide Division Erosion Control Department Public Works research Institute Ministry of Construction	Leader (Landslide Expert)
2. Mr. Ikuo FUJIMORI Farm Road Improvement Coordinator Land Development Division Construction Department Agricultural Structure Improvement Bureau Ministry of Agriculture, Forestry and Fisheries	Member (Irrigation Expert)
3. Mr. Takashi INOKUCHI Senior Researcher Disaster Prevention Research Division National Research Institute for Earth Science and Disaster Prevention Science and Technology Agency	Member (Landslide Expert)
4. Mr. Takashi YAMADA Research Engineer Erosion Control Division Public Works Research Institute Ministry of Construction	Member (Debris Flow Expert)
5. Mr. Kenzo HIROKI Director & Chief Senior Researcher Planning Department Japan Dam Engineering Center	Member (River Engineering)
6. Mr. Takashi MUROMOTO Senior Research Engineer The Japanese Institute of Irrigation and Drainage	Member (Irrigation Expert)
7. Mr. Shun'ichi MURATA Coordinator Japan International Cooperation Agency (JICA)	Coordinator

3.2 Itinerary

The following is the schedule followed by the relief team.

Aug. 25 (Wed.)

11:00 Tokyo - Bangkok by TG-641

Aug. 26 (Thu.)

10:40 Bangkok-Kathmandu by RA-408

15:00 Courtesy call and Meeting in the Embassy of Japan

16:00 Meeting for confirmation of the schedule and information on disaster situations

Aug. 27 (Fri.)

10:30 Courtesy call and Meeting in the Ministry of Water Resources

14:00 Courtesy call and Meeting in the Ministry of Finance

14:15 Donors Meeting chaired by the World Bank

15:00 Courtesy call in the Ministry of Home

16:00 Courtesy call in the Ministry of Works and Transport

16:30 Meeting of disaster situation with World Bank personals

Aug. 28 (Sat.)

09:00 Reconnaissance survey by a helicopter of the affected areas (East Rapti River, Bagmati River, Kamala River Basin and Sapta Koshi River)

<River Training and Irrigation Team>

16:00 Landing in the Bharatpur airport

Meeting with the East Rapti Irrigation Project staffs

Meeting with the CDO of Chitwan District

Stay in Bharatpur

<Debris Flow and Landslide Team>

15:30 Landing in the Nibuwatar

16:00 Reconnaissance of No. 2 Power Station Area

Stay in Nibuwatar

Aug. 29 (Sun.)

<River Training Team>

07:00 Bharatpur - East Rapti River (Piple Village, Lothar River)-Manohari River - Hetauda - Bhainse (Kulekhani No. 2 Power House) - Hetauda - Birganji

Stay in Birganji

<Irrigation Team>

07:00 Bharatpur - East Rapti River Basin - Eastern Canal of Bagmati Irrigation Project - Birganji

Stay in Birganji

<Debris Flow and Landslide Team>

09:00 Survey of Chisapani River basin and Upper Jurikhet Landslide Area

16:00 Survey of Mandu basin

Stay in Nibuwatar

Aug. 30 (Mon.)

<River Training Team>

07:00 Birganji - Narayani Irrigation Project Office - Bagmati Barrage (Bagmati Irrigation Project Office) - Gaur (Meeting with the CDO of Rautahat District) - Ring Bund in the Indian territory - Birganji

Stay in Birganji

<Irrigation Team>

07:00 Birganji - Bagmati Barrage - Western Canal of Bagmati Irrigation Project - Kamala Barrage on the right bank - Janakapur

Stay in Janakapur

<Debris Flow and Landslide Team>

07:00 Survey of Khani river basin and Rapti main river

14:00 Survey of Valve House and Penstock area

Stay in Nibuwatar

Aug. 31 (Tue.)

<River Training Team>

07:00 Birganji - Malangawa (Meeting with CIO of Sarlahi District) - Bagmati River at Karmaya. Rigat and Shankarpur Village and District Irrigation Office (DIO) - Janakapur

Stay in Janakapur

<Irrigation Team>

07:00 Janakapur - Kamala Barrage on the left bank - Main canal - Biratnagar

Stay in Birathnagar

<Debris Flow and Landslide Team>

07:00 Move to Palung - Survey of Palung area

Stay in Kathmandu

Sep. 01 (Wed.)

<River Training Team>

07:00 Janakapur - Siraha District (Meeting with the CDO of Siraha District) - Kamala River at Sarswar and Basbitta Village with DIO - Birathnagar

Stay in Birathnagar

<Irrigation Team>

09:00 Departure from Biratnagar Airport

11:30 Arrival at Kathmandu Airport

Stay in Kathmandu

<Debris Flow and Landslide Team>

09:00 Survey of Prithvi Highway from Kathmandu to Mugling

Stay in Kathmandu

Sep. 02 (Thu.)

<River Training Team>

09:00 Departure from Biratnagar Airport

11:00 Arrival at Kathmandu Airport

Stay in Kathmandu

<Irrigation Team and Debris Flow and Landslide Team>

Preparation of the Report

Sep. 03 (Fri.)

Report making

15:00 Discussion on the reports with the Committee for Case Study on Floods in Bagmati Basin.

Sep. 04 (Sat.)

Preparation of the Report

Sep. 05 (Sun.) 13:00

13:00 Meeting and presenting HMG/N a draft of the recommendation in the Finance Ministry

Sep. 06 (Mon.)

13:40 Kathmandu - Bangkok by TG312

Stay in Bangkok

Sep. 07 (Tue.)

11:00 Bangkok - Narita by TG640

4. Findings and Recommendations of River Training Expert Team

4.1 Findings and Technical Advice on the East Rapti River

4.1.1 Breaching process of the right embankment in Piple Village

The severest damage in the Rapti River catchment was caused by breach of the right embankment in Piple Village. 830 meters of dyke was completely destroyed after it was overtopped by a flood of an unprecedented scale. The entering flood formed two main streams, which isolated the village, killed 47 people and washed away 1,700 ha of farm land.

4.1.2 Technical advice on the rehabilitation of the right bank in Piple Village

(1) Determination of the peak flood discharge

The peak flood discharge currently assumed by the DOI field office is based on an emergency survey and rough calculation. As accurate estimation of the peak flood discharge is determinant factor when formulating a revised master plan of the river, the following investigation and study are recommended to make the estimation of the discharge more accurate:

(a) Cross sections of the riverbed should be made by pitch of 200 meters in the areas between 2 kilometers upper and lower streams of the breached dyke.

(b) A field survey on flood markings should be executed in the river sides between 2 kilometers upper and lower streams of the breached dyke. A longitudinal section of flood markings should be made.

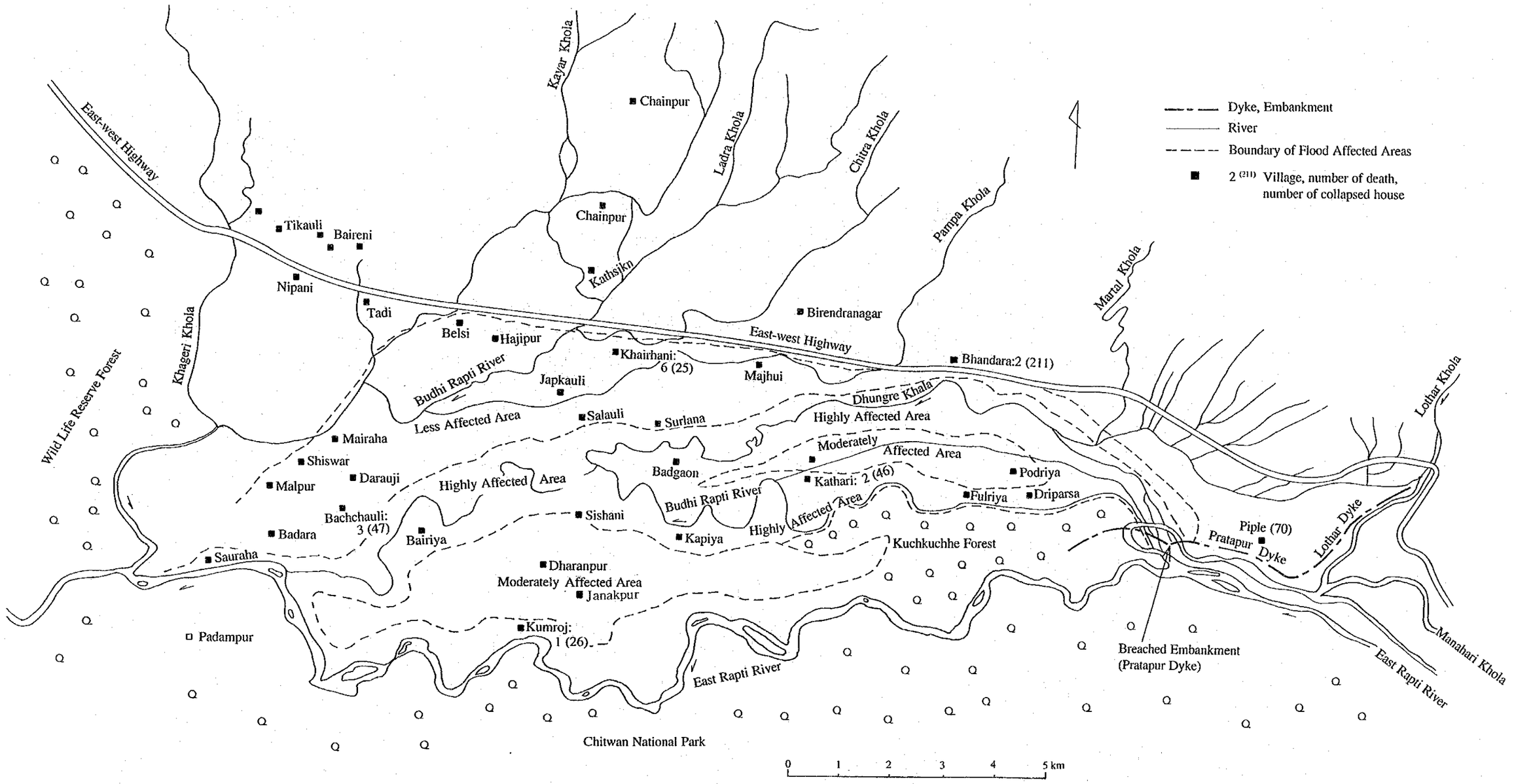
(c) Diameters of sediments in the riverbed should be investigated. Roughness of the riverbed should be estimated taking into account the diameters of the sediments, etc.

(d) Based on the investigation of (a) and (c), simulation based on the non-uniform flow equation should be done to obtain longitudinal water levels of floods of different discharge.

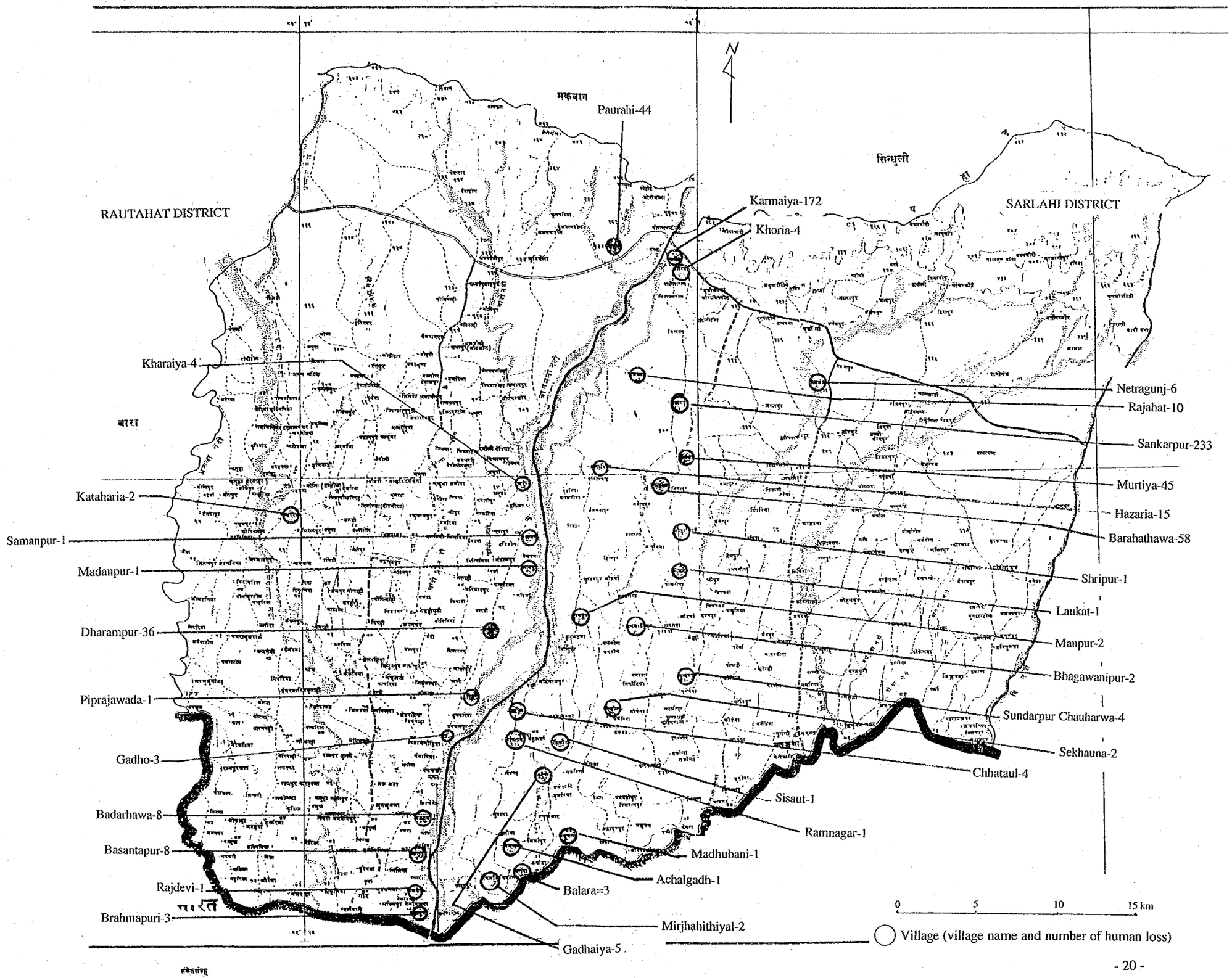
(e) By comparing the flood marking in (b) and the result of the calculation in (d), the peak discharge should be determined.

(2) Size and fillings of the new dyke

As the size of the old dyke was inappropriate to resist such a big flood as the July Flood, the width of the top of the new dyke should be planned longer, and in accordance with the size of the revised design flood discharge. The breached dyke was on an old river course, and settled after the completion. Thus, the plan of the new dyke should take into account an effect of settlement on an old river course. Fillings of the dyke should consist not of boulders and sands but of silts and sands. The necessary silts and sands can be provided from the riverbed in front of the downstream part of the disappeared dyke.



Location Map of East Rapti River


RAUTAHAT DISTRICT
SARLAHI DISTRICT
मकवान
सिन्धुली
बारा
Paurahi-44
Karmaiya-172
Khoria-4
Kharaiya-4
Netragunj-6
Rajahat-10
Sankarpur-233
Murtiya-45
Hazaria-15
Barahathawa-58
Shripur-1
Laukat-1
Manpur-2
Bhagawanipur-2
Sundarpur Chauharwa-4
Sekhauna-2
Chhataul-4
Sisaut-1
Ramnagar-1
Madhubani-1
Achalgadh-1
Balara=3
Mirjhahithiyal-2
Gadhaiya-5
Kataharia-2
Samanpur-1
Madanpur-1
Dharampur-36
Piprajawada-1
Gadho-3
Badarhawa-8
Basantapur-8
Rajdevi-1
Brahmapuri-3
भारत
0 5 10 15 km
Village (village name and number of human loss)

(3) Removal of the island in the river

The island in front of the breached dyke currently covered by a forest should be removed so that it would not dam up future floods.

(4) Alignment of the new dyke

Alignment of the old dyke which was planned in accordance with the current master plan can not properly deal with such a big floods as the July Flood. Alignment of the new dyke proposed by the district irrigation office seems to be appropriate, though its effectiveness should be reconfirmed by a water level simulation based on non-uniform flow equation.

(5) Size of spurs

New spurs should be longer and the most important spurs should be made of concrete, if available.

(6) Review of the master plan

As the existing masterplan is no longer viable, revised master plan should be formulated as soon as possible.

4.2 Findings and Technical Advice on the Bagmati River (downstream of the Bagmati Barrage)

4.2.1 Damage in the catchment area

The team's investigation on the damage in the Bagmati River was focused on the left bank side where the damage was the severest. Four kilometers of the left side of the Bagmati River down from the East-West Highway Bridge was overtopped by the July Flood. The average maximum water depth at the river side is presumed to be more than two meters.

The deathtoll is the highest in the north west part of the Sarlahi District. The overtopping flood ran through Karmaya, Rajgat and Shamkarpur VDC, and 415 people were killed.

Tekani of Rajgat VDC is located in the left side of the old river course of the Bagmati River. 500 meters of the bank were overtopped. The forest area in the left downstream side is bottlenecking the river. The bottleneck dammed up the flood flow, and raised the water level of the river in the overtopped site. The scour in the downstream riverbed proves the dam-up phenomena. The extent of damage differs according to the depth of the spilled flood. Houses completely disappeared in the area where main flood ran through while they were less affected in the surrounding area. Most of the killed people were carried away by the flood while sleeping. Shamkarpur VDC had the loss of 233 people. According to the villagers, flood flow came first from the direction of Tekani. After that, bigger flow came from the direction of the East-West Highway Bridge. In the peak time, water came from West to NNW, immersing the areas by depth of more than two to three meters on average. The situation was aggravated by lack of high platforms for evacuation and sudden onslaught of the flood at midnight.

Lack of information on the flood was, to no less extent, contributing to loss of human lives.

4.2.2 Technical advice on the rehabilitation works in the Bagmati River

The affected people living in provisional shelters have to be resettled soon. Some of those people may abandon their original lands and move to newly developed areas. In that case, however, friction between new and old inhabitants is inevitable, and deforestation accruing from the new settlement may aggravate soil erosion, increase flood discharge, and a new vicious-circle will begin. Resettlement in their home lands is, therefore, basically the best solution. It is a prerequisite for resettlement in their original lands to assure them safety of their place.

Emergency civil works such as rivetment of riversides and closure of the flood streams are needed immediately. The team proposes the following points for smooth, economical rehabilitation activities.

(a) Use of earth works.
The most economical works in this country are earth works. Enlarged size of the bank can economically enhance the safety level of the flood control facilities.

(b) Use of hydraulic characteristics of rivers.
Basic hydraulic characteristics of river flow can be effectively used to pursue economical solution for flood control. Excavation of bottlenecking places, for example, can facilitate smooth and quick discharge of the river flow. A barren land along the river can be used as a retarding basin by raising the embankment on the opposite side of the river. Backward placement of the dyke is effective not only because it enlarges the river area but because the platform outside (riverside) the dyke can work as a protection of the dyke. The team advises that emergency civil works be planned and executed taking into account basic hydraulic characteristics of rivers.

4.3 Findings and Technical Advice on the Kamala River

4.3.1 Damages in the catchment area

The team investigated Basbitta and Sarswar VDC, two of the most affected areas in the Kamala catchment area. Peak discharge of 7,229 m^3/sec was recorded in the Kamala barrage point. Areas along the left side of the river were overtopped and some dykes were breached. Though there was no loss of human life, 17 VDC were affected.

4.3.2 Technical advice on the rehabilitation works in the Kamala River

One of the characteristics not only of the Kamala but of the rivers in the Terai is heavy sedimentation. The left side of the Kamala River in the Basbitta is being rapidly eroded by the main stream detoured by sedimentation. Though concrete spurs, revetments or footings which are commonly employed in Japan and other countries may not be easily applied in Nepal, these works can be considered as alternatives after taking into account their economic viability. The rehabilitation works in Basbitta and Sarswar should be dealt with in consultation with the Disaster Prevention Technical Center (DPTC).

4.4 The Bagmati Barrage

4.4.1 Outline of the barrage

The Bagmati Barrage is located in the top of the alluvial fan of the Bagmati River. The barrage provides irrigation water to 68,000 ha of farm lands on the both sides of the river. The total length of the barrage is 403.5 meters, and it is equipped with 36 main gates.

4.4.2 Damages in the surrounding area

(1) The right side

500 meters of the right (west) side of the river down from the barrage was overtopped by the July Flood. The major part of the spilled water seems to have joined the main river just downstream from the barrage. However, some of the flooding water reached the East-West Highway and a portion of it breached the highway and went further downstream. The river side area as wide as 120 meters and as long as 500 meters was washed away. 48 human lives were lost.

(2) The left side

60 meters of the ring bund on the left (east) side of the river was overtopped by the flood. Part of the spilled water ran through the irrigation canal towards the east area of the river. The area as long as 500 meters and as wide as 60 meters between the barrage and the East-West Highway Bridge was washed away. 8 people in the Bagmati Barrage Project Office were killed.

(3) The peak water level

All the main gates of the barrage were placed in the full-open position at 11:00 PM on July 19, 1993, more than 24 hours before the occurrence of the peak water level, according to field engineers. The recorded highest water level (136.95 meters) seems to be fairly reliable since drifting objects are seen hooked along the hoisting wires of the gates, the lowest end of which is 136.7 meters, but not seen on the top cat walk (140.7 meters), and the logs are seen between the top cat walk and the upper end of the gates.

4.4.3 Recommendations on the evaluation of the peak discharge

The peak discharge is the most decisive factor when designing the rehabilitation plan of the river as well as that of the barrage. Currently, a tentative peak flood discharge of 15,000 m^3/s was suggested after provisional estimation. The estimation is based on a rating curve of the river at the water level gauging station in a place 1.5 kilometers upstream from the barrage. This tentative figure as well as the estimation method should be reviewed because of the following reasons:

Siraha District (Kamala Rivr left bank)

Data of Damages to Kamala River Flood on 050-4-5 and Distribution of Relief Materials in Siraha

S. No.	V.D.C.	No. of Homeless Family	No. of Family Simply Damaged	Loss of Land and Crops			Cost of Crops Damaged	Livestock		Distribution to Homeless Family under relief work		Medical Treatment	Remarks
				Area	Cost	Family		No.	Cost	From District Disaster Section	From Red Cross		
1	Madar	11	117	56-17-0	–	156	291430	–	–	Rs. 500/family	1 set utensil & 1 set cloth	Medically treated by health team	Land simply damaged
2	Lagadigoth	2	70	–	–	–	–	–	–	"	"		"
3	Sukhachina	1	49	58-11-0	–	208	296425	–	–	"	"	"	"
4	Khiruna	6	82	26-10-10	–	117	112955	–	–	"	"	"	"
5	Makhanaha	1	32	12-7-10	–	33	34795	–	–	"	"	"	"
6	Nanpur	2	24	2-17-0	–	19	10930	–	–	"	"	"	"
7	Sarswar	8	29	202-16-10	17780	139	411275	–	–	"	"	"	Land covered by sand & eroded by river
8	Basbitta	2	61	357-10-0	284130	170	786520	14	22000	"	"	"	
9	Bishnupur P.R.	0	27	–	–	–	–	–	–	"	"	"	"
10	Chatari	4	26	102-9-0	24310	148	483700	–	–	"	"	"	"
11	Bhokkaha	1	10	272-7-0	281050	119	470305	4	8000	"	"	"	"
12	Rikana	7	159	262-14-0	258830	364	758100	2	10000	"	"	"	"
13	Bhediya	16	61	432-0-10	571285	266	829470	–	–	"	"	"	Land simply damaged
14	Malhaniya Ga.	5	64	10-17-0	–	26	47095	–	–	"	"	"	"
15	Thalhakatta	1	6	–	–	–	–	–	–	"	"	"	"
16	Bishnupurkatti	1	12	–	–	–	–	–	–	"	"	"	Land covered by sand & eroded by river (simply damaged)
17	Itariprasahi	0	0	329-3-0	224730	226	701600	–	–	"	"	"	
18	Laxminiya	0	0	5-19-0	–	36	19310	–	–	"	"	"	"
19	Siraha	0	0	9-16-90	–	41	94845	–	–	"	"	"	Loss of fish pond due to entering the flood
20	Badaharamal	12	23	–	–	–	–	–	–	"	"	"	
		80	852	2142-15-10	1822205	2060	5348755	20	40000				

Evaluation of Loss of Property and Crops by Flood (in Rs.)

S. No.	V.D.C. and Ward No.	No. of Farmers	Area of crops damaged		Rice Plantation		Rice Plant		Marize		Millet		Fruits (banana)		Vegetables		Chili		Fish ponds		No. of animals washed away		Remarks
			Area	Cost	Area	Cost	Area	Cost	Area	Cost	Area	Cost	Area	Cost	Area	Cost	Area	Cost	Area	Cost	No.	Cost	
1	Lamiria - 1,2	36	–	–	4-0-0	88000	4-0-0	88000	0-12-0	3600	00-12-0	3600	0-2-0	3600	–	–	0-1-0	150	–	–	–	–	
2	Bhadar - 1 to 9	156	–	–	15-0-0	33000	15-0-0	33000	18-0-0	108000	18-0-0	108000	0-11-0	108000	1-2-0	8250	0-12-0	4800	2-0-0	30000	–	–	
3	Bhakhanaha - 1,3	33	–	–	10-0-0	22000	10-0-0	22000	1-1-0	6300	1-1-0	8300	–	8300	0-2-0	750	7-1-0	225	–	–	–	–	
4	Bharpur - 1,2,3	19	–	–	1-0-0	2200	1-0-0	2200	0-5-0	1500	0-5-0	1500	–	1500	0-6-0	2250	0-14-0	3102	–	–	–	–	
5	Malhania Gamharia	26	–	–	4-0-0	8800	4-0-0	8800	3-2-0	18600	3-2-0	18600	–	18600	0-3-0	1135	0-3-0	450	–	–	–	–	
6	Khitauna - 1 to 9	117	–	–	14-0-0	30800	14-0-0	30800	4-2-0	24600	4-2-0	24600	–	24600	0-10-0	3750	0-3-10	525	1-10-0	22500	–	–	
7	Sukhachaina - 1 to 9	208	–	–	86-0-0	22000	86-0-0	22000	34-0-0	204060	34-0-0	204060	–	204060	0-7-0	2625	0-4-10	600	–	–	–	–	
8	Sataswan 1,2,3,4,7,8,9	134	80-17-0	177870	150-0-0	189200	150-0-0	189200	14-4-0	85200	14-4-0	85200	–	85200	2-8-0	18000	2-4-10	6675	2-14-0	40500	–	–	
9	Basabiha - 1 to 9	170	129-3-0	284130	44-0-0	330000	44-0-0	330000	46-0-0	276000	46-0-0	276000	–	276000	0-16-0	6000	0-13-0	1950	2-5-0	33750	14	2200	Buffalo-1, Calf-2, Goat-3, Smaligoat-4, She goat-4
10	Chatan - 1 to 9	148	11-1-0	24310	188-0-0	96800	188-0-0	96800	10-8-0	62400	10-8-0	62400	–	62400	–	–	3-8-0	7200	7-10-0	7500	–	–	
11	Itari Pasahli 2,5,7,8,9	226	102-3-0	224730	56-0-0	413600	56-0-0	413600	33-0-0	198000	33-0-0	198000	–	198000	–	–	–	–	6-0-0	33750	–	–	
12	Bhicia - 1 to 9	266	259-13-10	571285	103-0-0	123200	103-0-0	123200	61-0-0	366000	61-0-0	366000	–	366000	21-0-0	157500	1-14-0	5650	2-2-0	7500	2	10000	Cow-2
13	Bhokraha - 1 to 9	111	127-15-0	281050	24-0-0	226600	24-0-0	226600	16-0-0	96000	16-0-0	96000	–	96000	8-7-0	82625	–	2250	0-4-0	90000	–	–	
14	Chikana 1,2,4,6,7,8,9	364	117-13-0	258830	–	52800	–	52800	80-0-0	360000	80-0-0	360000	–	360000	19-2-0	143250	0-15-0	–	0-4-0	31500	4	8000	Calf-3, Goat-1
15	Sihaha - 5,7,8	41	–	–		–		–	3-8-0	20400	3-8-0	20400	–	20400	–	–	–		4-5-10	3000	–	–	
	Total	2060	828-5-10	1822205	709-0-0	1559600	709-0-0	1559600	305-2-0	1830600	305-2-0	1830600	0-13-0	1830600	54-3-0	406135	0-16-10	32475	21-14-10	3000	20	40000	Total Cost = Rs. 7210960

(a) Most of the water level data which the existing rating curve is based on had been obtained before 1992 when the barrage was completed. The rating curve after the completion of the barrage is to a large extent different from the existing one, as the barrage dams up river flow, affecting the water level at the gauging station.

(b) As many driftwoods blocked the gates and hindered the flow through the gate in July Flood, the discharge through the barrage at the time of the peak water level cannot be estimated. Therefore, modification of the existing rating curve is hardly possible.

(c) Few of peak flood velocities have been measured at the gauging station site due to unavailability of appropriate site and financial resources. Therefore, a flood part of the rating curve covering flood discharge is unreliable.

(d) The tentative peak flow calculation is based on the cross section of the river bed measured before the July Flood. As the shape of the riverbed might have been changed by the flood, the estimated tentative discharge may, to a large extent, differ from the true figure.

The team, therefore, recommends that the tentative figure be abandoned and the simulation method based on the non-uniform flow equation be used to determine the peak discharge of the July Flood. The execution plan of the survey and simulation is as follows:

(a) A flood marking survey should be done in the both sides of the river from the barrage to the point five kilometers upper than the barrage.

(b) Cross sections should be made every 200 meters in the riverbeds from the barrage point to the point five kilometers upper than the barrage.

(c) The roughness of the river bed should be estimated by investigation of diameters of sediments in the riverbed, etc.

(d) The simulation of water levels based on the non-uniform flow equation should be executed using the result of (b) and (c).

(e) The longitudal water level sections obtained respectively through (d) and (e) should be compared. A discharge of which simulated water levels in (d) are closest to those obtained by the flood marking survey should be decided as the peak discharge.

As the surveys and studies mentioned above require deep knowledge and wide range of experience on the part of the researchers, it is recommended that DPTC be consulted throughout the survey and the simulation.

4.5 Recommendations

Despite the fact that the Bagmati, the East Rapti and the Kamala Rivers are considered as major rivers in Nepal, few river training works other than a few patch-work jobs for erosion control have been done in these rivers. The July Flood taught a lesson that social stability and economic development will be badly affected by floods unless full-scale flood control measures are taken. On the other hand, practical and phased approach should be proposed if the financial constraints of HMG/N and the difficult economic situation of the country are taken into account. The team, therefore, recommends HMG/N three phased measures on rehabilitation of river training facilities and improvement of the flood control sector.

4.5.1 Emergency measures

(1) Provision of necessary equipment and materials

A certain amount of heavy equipment and materials for river training have been stocked in the district irrigation offices, project offices, etc. in Nepal. The Government of Japan has also cooperated in this sector. Gabion wires and relating equipment have been granted by GOJ since 1988. However, enormous demand for heavy equipment and materials occurred after the July Flood, and the demand is currently much exceeding the stock. Current requirement for the materials and the equipment should be reviewed. Although the demand should be principally satisfied by HMG/N, the concerning donors should be aware of the current difficult situations. TOR on the required heavy equipment and materials is attached in the Appendix-A.

(2) Development of warning systems and shelters

As mentioned earlier, people's unawareness of the threat of floods and lack of precautions increased the number of human loss and other damages in this cataclysm. Software measures such as a flood warning system is vital for prevention of recurrence of the tragedy. The Bagmati Barrage can be used as an effective monitoring point for the warning system in the Bagmati catchment area, as it is located at the top of the Bagmati alluvial fan in the Terai. People's participation programme in the flood control sector should be incorporated in the warning system, as people's awareness of threat of disaster is indispensable for long-standing and effective warning system. As the Terai plain comprises vast flat lands, high places for evacuation are necessary to make the flood warning system functionable. The areas where there are no such high places or where floods tend to isolate villages should be identified for allotment of artificial platforms. Simple shelters with warning equipment should be constructed on these platforms. It is desirable if the areas surrounding these platforms are afforested. The platforms and shelters can be usually used for educational or communal purposes. TOR on the flood warning system and the platforms and shelters will be attached in the Appendix-B.

(3) Improvement of hydrological observation network

Hydrological data (rainfall, water level, discharge, sediment) are essential for the proper design of infrastructures to avoid such serious damages as caused by the disaster of July 1993.

In Nepal, however, the hydrological network is not adequate in terms of density and reliability, although efforts have been made to improve the network by DHM with foreign assistance. For example, the number of rainfall station is 252 e.g. 580 km^2/one station, of which automatic recording type are only 14 stations. Further, most of them were set up in recent 10 to 20 years.

As water sources development is a key sector for the economic and social development of the country, further efforts to improve hydrological network should be made as soon as possible.

It is recommended that improvement of hydrological network should be made steadily in accordance with "The Study on Nationwide Hydro-Meteorological Data management Project, March 1993, JICA", serious damages took place in irrigation facilities and other infrastructures. TOR of the project will be attached in the Appendix C.

(4) Actions to be taken by HMG/N

(a) Promotion of river training works

The flood in July 1993 caused a great loss of lives together with their houses; vast area of fertile land were either washed away or buried by sand and debris; a number of infrastructures were damaged seriously. Impact of the magnitude of the flood was one of the biggest ever experienced in Nepal, the loss and damage might have been much less if more river training works should have been provided at strategic sites and in a proper way.

Some people have now started reconstruction of houses in the original places, but they will be easily affected again by even smaller floods without protection works; others are thinking to abandon their home to move to safer places as river training works require too much burden for the affected people to bear without substantial inputs from the government.

In view of heavy damage caused by the disaster, some drastic measures should be taken to promote flood prevention works. However, it is not realistic to implement river training works covering the whole territory of Nepal, though the government is fully aware of the necessity. It is therefore recommended to implement river training works with priority first on affected areas whenever severe disaster takes place, so that such areas will never be affected by floods of similar magnitudes in future. By repeating such exercises after disaster at different areas, Nepal will, in the long run, become a country from disaster-prone to well prepared against floods.

It is recommended that:

River training works are essential prior to rehabilitation works in affected areas. Therefore, river training plans should be drawn up as part of disaster rehabilitation plan for implementation as early as possible. Such plans should cover not only major rivers but also small rivers.

River Training Division of DOI should be strengthened institutionally in terms of manpower as well as budget. DIOs should also be strengthened so that they may be able to play more important roll at district level, not merely distributing gabions at the request of villagers.

(b) Financial Arrangements

The July Flood has depleted financial resources of the DOI field offices which have taken responsibility of river training. Even fuel cost to transport boulders for gabion works are not available. The financial constraints at the field level are starting to tightly clutch disaster rehabilitation activities in many areas. HMG/N should make financial arrangements to expedite smooth rehabilitation activities. Utilizing counter funds of commodity aid is an effective way of solving the problem. People's participation program supported by food aid also can be an effective solution.

(c) Maintenance of flood prevention facilities

In some areas, people have broken the gabion crates and taken away the filling boulders for their personal use. Some dykes have been dug by people and left without repairment. HMG/N is advised to enhance the awareness of people on the importance of flood prevention facilities. Responsible field offices should monitor the safety of flood control facilities and properly maintain them.

4.5.2 Middle-term measures

(1) Review of the Master Plan for flood control in the East Rapti, the Bagmati and the Kamala Rivers

A master plan for river training in the Bagmati River was completed by Narayani Irrigation Office, DOI in 1991. The July Flood may have made this master plan obsolete since its discharge seems to have exceeded the designed one in the M/P. The river courses as well as the contours of the riverbed seem to have been changed. Therefore, review of the M/P is urgently needed. The technical points suggested in 4.1, 4.2, and 4.3 should be taken into account when formulating a new M/P.

The team recommends that the review of the M/Ps in the Bagmati, the East Rapti and the Kamala be executed simultaneously and as soon as possible. TOR of the M/Ps will be attached in the Appendix-D.

(2) A full-scale flood control project in the left bank of the Bagmati River

The overtopping of the July Flood in the four kilometers of the Bagmati east river side in Takani and Karmaya caused the largest and the severest damage in Nepal. A full-scale flood control project should be started in a few years to normalize the people's lives and stabilize the economy of the affected areas. Special attention should be paid to the design flood discharge, closure of the old river course of the Bagmati, distance of backward displacement of the dyke and treatment of the island in the river. The project should be coordinated with the reviewed M/P. The M/P should also place priority on the project so that the part of the M/P relating to the project is given a F/S status.

4.5.3 Long-term measures

(1) Actions to be taken by HMG/N

Despite its importance, the river training sector has suffered financially and organizationally in Nepal as conspicuous projects tend to have been given priority and claimed bulk of financial and human resources. Meager budget has been appropriated to the sector in the past, and unfairly little attention has been paid to it. Meanwhile, difficult geographical and geological conditions exerted a regressive pressure on the development activities in the country. Currently, the river training sector is dealt by the River Training Division, DOI. In the field level, district irrigation offices, project offices, etc. are constructing river training works. Most of those works are mere components of irrigation or road projects. The field engineers are little aware of the fact that river training is one of the basic sectors which bolster nation-wide economic development. To alter the current situation like these, institutional building should be strengthened and in-house river engineers should be nurtured. In this sense, the role of DPTC can be enlarged so that it becomes the core of flood-control and soil erosion control activities. For those rivers which are important in terms of economic and social development of the country and require considerable river works, establishment of River Training Office should be considered.

REVIEW OF THE HEAVY EQUIPMENT AND MATERIALS FOR FLOOD REHABILITATION AND RIVER CONTROL WORKS

TERMS OF REFERENCE

(Draft)

TERMS OF REFERENCE
FOR
HEAVY EQUIPMENT AND MATERIALS
FOR
FLOOD REHABILITATION AND
RIVER CONTROL WORKS

Project Title	:	Heavy Equipment and Materials for Flood Rehabilitation and River Control works
Location	:	To be Stocked at Birgunj for Use in Rivers of Central Region
Executing Agency	:	Department of Irrigation, Ministry of Water Resources

1. Background

The torrential rains from 19 to 21 July 1993 caused extensive damage by floods, debris flows and landslides in various parts of the country, especially in Central Region. The disaster was the worst in the history of Nepal, claiming human loss of 2,155 persons including 1,000 missing. Properly damage to various sectors has been provisionally estimated at about Rs. 4.2 billion, which will become even higher when the detailed assessment is completed.

A number of villages were seriously affected, some due to breaching of embankments while others due to absence of embankments and other protective works. Those villages are now more susceptible to floods than before and will be easily affected by even smaller magnitude of floods.

Therefore it is necessary to rehabilitate the embankments, spurs, revetments, etc. and to construct new ones before the next monsoon season, at least at strategic sites selected on priority basis.

In order to carry out those works within the limited time, heavy equipment, gabion wires and metal forms for concrete blocks as quantified in 3. below are required as soon as possible.

2. Objective

The objective of this project is to mitigate flood damage by facilitating rehabilitation works of embankments, etc. damaged by the floods of July 1993.

3. Outline of the Project

(1) Heavy equipment as quantified below

Heavy equipment as quantified below are required for rehabilitation and construction of embankments, excavation of river bed where heavy siltation caused flooding, transportation of gabions etc.

Description	Quantity	Unit Cost R.	Amount Rs.
1) Caterpillar Bulldozer Blade length 5.2 m Capacity 3.89 m^3	5 Units	7,000,000 (132,000)	35,000,000 (660,000)
2) Caterpillar Wheel Loader model 926 Capacity 1.9 m^3	5 Units	6,000,000 (120,000)	30,000,000 (600,000)
3) Dump Truck 10 tons	10 Units	2,000,000 (40,000)	20,000,000 (400,000)
4) Caterpillar Hydraulic Excavator model E 140 Capacity 0.5 m^3	2 Units	6,000,000 (120,000)	12,000,000 (240,000)
5) Fast Moving Spare parts (15% of equipment cost)			14,550,000
		Sub Total	111,550,000 (2,231,000)
(Transport Equipment)			
6) Pick up	5	1,000,000	5,000,000
7) Motor cycle	10	75,000	750,000
8) Low bed Truck Trailor Capacity 20 tons	1	5,000,000	5,000,000
9) Tools and Tackles		1,000,000	1,000,000
		Sub Total	11,750,000
		Grand Total	123,300,000

(2) GI Wire

Although the damage assessment has not been completed, the quantity of GI wire required for flood rehabilitation works is provisionally estimated as 4,260 MT according to reports from Districts and Projects as follows (as of mid-September 1993):

This amount may increase as damage assessment continues, however, immediate requirement has been estimated as 1,500 MT (about one third, considering available local resources and transportation capacity), for which the grant aid of the Government of Japan is solicited.

This amount of GI wire is required as early as possible fin addition to those being provided by Japan annually since 1988.

In the meantime, GI wire provided by Japan and presently reserved at various Regions will be diverted to the five most affected Districts in Central Region on priority basis as in Annex 1, which will be compensated later when the Japanese grant aid will be realized.

District/project	Demand (MT) District/project	Food for work	Total
1. Sindhuli	600	200	800
2. Kathmandu	–	–	–
3. Lalitpur	–	–	–
4. Dolakha	5	–	5
5. Dhading	100	–	100
6. Makawanpur	1,000	150	1,150
7. Chitwan	15	100	115
8. Sindhupalchock	–	–	–
9. Kabharepalanchock	–	–	–
10. Jhapa	100	–	100
11. Sarlahi	40	150	190
12. Rautahat	0	100	100
13. Nawal Parasi	100	–	100
14. Rupandehi	600	–	600
15. East Rapti, Kamala, Bagmati, Khando, Rakhandehi, Lalbakaiya Projects	1,700	–	1,700
Total	4,260	700	4,960 MT

This amount may increase as damage assessment continues. However, immediate requirement has been estimated as 1,500 MT (about one third of the total, considering available local resources and transportation capacity), for which the grant aid of the Government of Japan is solicited. This amount of GI wire is required as early as possible in addition to those being provided by Japan annually since 1988.

In the meantime, GI wire provided by Japan and presently reserved at various Regions will be diverted to the five most affected Districts in Central Region on priority basis as in Annex 1, which will be compensated later when the Japanese grant aid is realized.

(3) Metal forms and equipment for concrete blocks

In Nepal, gabions have been popularly used for river works. However, there are many cases that they were damaged or washed away by floods. Therefore concrete blocks should be used at places where gabions could not or will not be able to withstand the floods, due to swift flow, deep scouring etc. in larger rivers such as Bagmati, East Rapti and Kamala.

Certain numbers of concrete blocks will be reserved at strategic sites of each river for emergency purposes.

Required materials and equipment is as follows:

1) Metal forms : 60 units (20 units each for 1 ton, 2 ton and 3 ton)
2) Equipment : Truck crane (capacity 24 tons) 2 units
   Concrete mixer (1.0 m^3) 2 units

4. Maintenance

Maintenance of heavy equipment will be under the responsibility of the Regional Mechanical Workshop located in the regional workshop complex of Narayani Irrigation Project, Birgunj. The Workshop is a new establishment to be operational from FY 1993/94.

The organization of the Mechanical Workshop is shown in Annex-2. One senior Mechanical Divisional Engineer is deputed from Irrigation Department. One Mechanical Engineer, a few senior Mechanics and Mechanics are deputed from Narayani Irrigation project to run the Workshop.

In order to supervise the Regional Mechanical Workshop, the Mechanical Section has been established in the Department of Irrigation. The organization is shown in Annex-3.

A budget of Rs. 5,147,000 has been allocated for FY 1993/1994 for maintenance and repair works.

Annex-1

Utilization and Stock Position of GI wire

Unit: Metric Ton

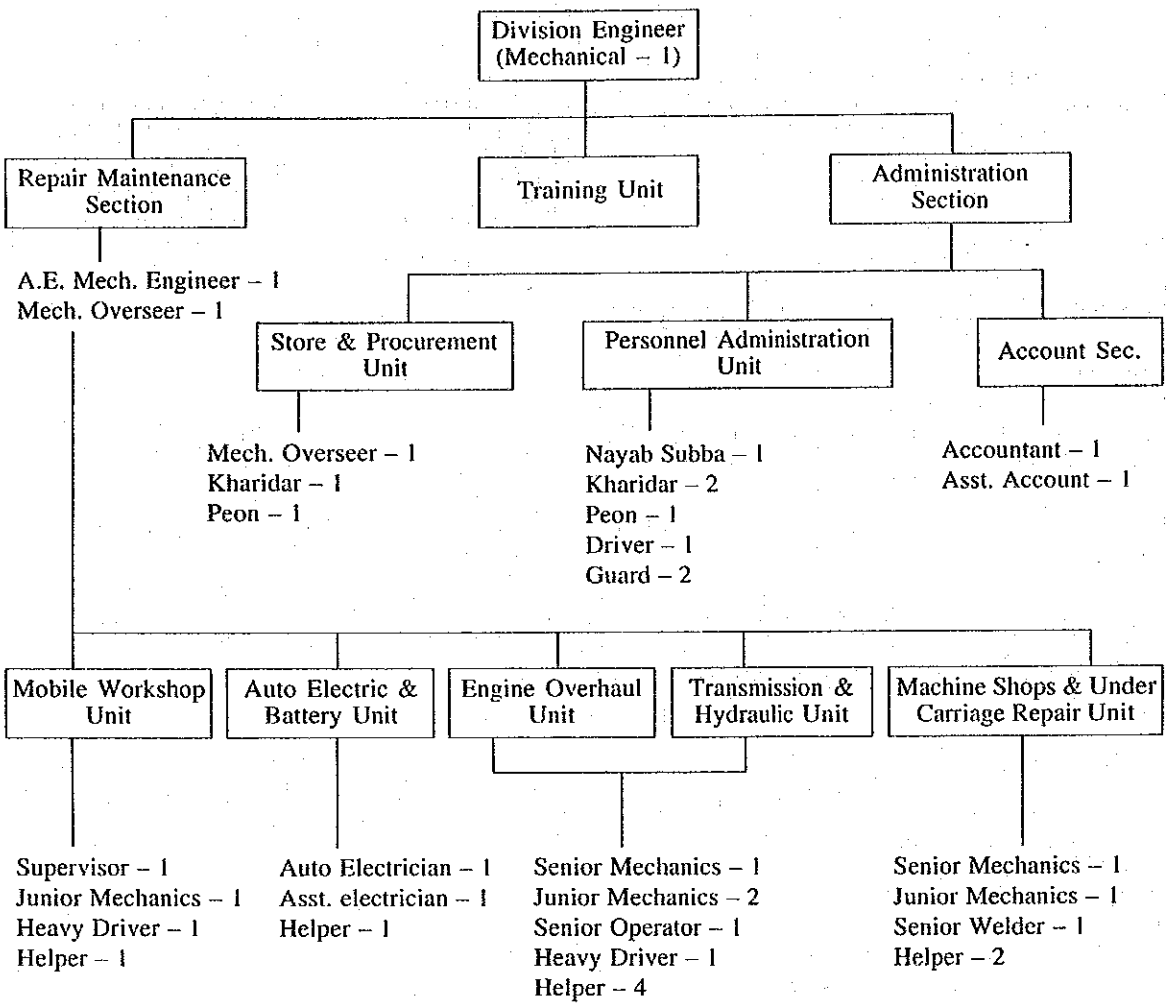
Region	Stock at the end of 1992/92 (15 July 1992)	Supply in 1992/93	Distribu-tion from Regional office 1992/93	Available Stock for 1992/93 5=2+3-4	GI wire Utilized up to the end of July 1993	Present stock Position of G. wire	Present Require-ment for flood rehabilita-tion	Regular require-ment	Remarks
1	2	3	4	5	6	7	8	9	10
Eastern	953	700	420	1,233	541	692	340	700	
Central	138	1,122		1,260	1,080	180	1,700	1,100	
Western	495	400	20	875	640	235	220	300	
Mid-Western	758	100	270	588	110	478	160	200	
Far-Western	541	200	100	641	432	209	180	200	
Total	2,885	2,522	810	4,597	2,803	*1,794	2,600	2,500	

1. Figures in col 7 indicate the stock position of G.I. Wire + Gabion boxes in Regional directorates.
2. *Out of 1794 M.T. of G.I. Wire Stock, 15090 M.T. will be distributed by central Reconstruction coordination committee (CRCC) to five districts in two phases.

1	Chitwan	100 T
2	Makwanpur	150 T
3	Rautahat	100 T
4	Sadahi	100 T
5	Sindnuli	200 T
	Total	700 T
	Reserve	800 T
	Grand Total	1,500 T

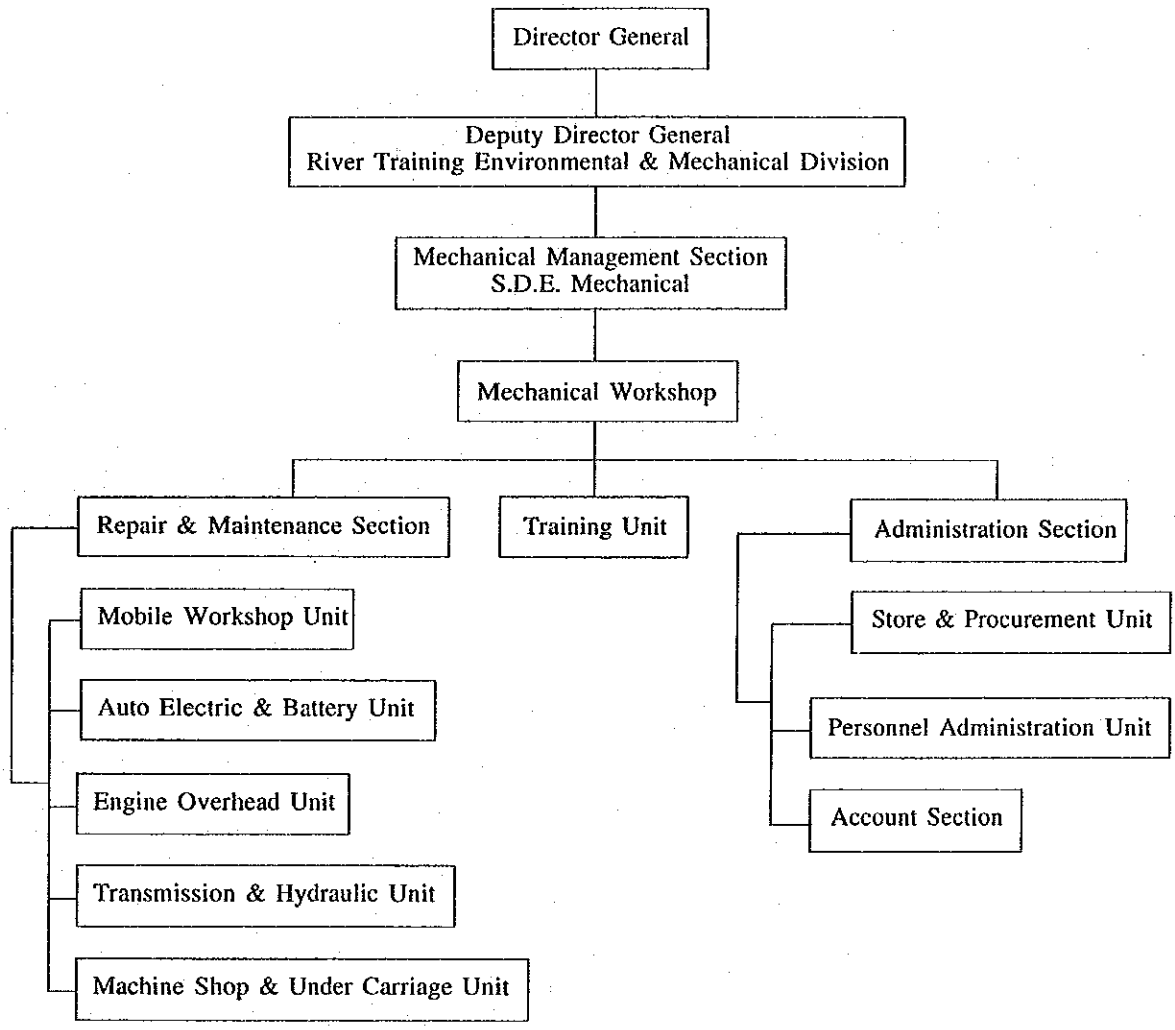
Annex-2

Mechanical Workshop



Annex-3

Department of Irrigaton



FLOOD WARNING AND EVACUATION SYSTEMS OF THE BAGMATI AND EAST RAPTI RIVERS

TERMS OF REFERENCE

(Draft)

TERMS OF REFERENCE
FOR
FLOOD WARNING AND EVACUATION SYSTEM
OF
THE BAGMATI AND EAST RIVERS

Project Title	:	Flood Warning and Evacuation System of the Bagmati and East Rapti Rivers
Location:		Flood-prone areas extending along the Bagmati and East Rapti Rivers in the Territory of Nepal
Executing Agency	:	Department of Hydrology and Meteorology, Ministry of Water Resources

1. Background

The torrential rains from 19 to 21 July 1993 (when maximum daily rainfall was 540 mm on 19 July at Tistung) caused extensive damage by floods, debris flows and landslides in various parts of the country. The disaster was the biggest of all which Nepal had ever experienced. Many villages were completely washed away by floods or buried by debris flows, claiming human loss of 2,155 persons including 1,000 missing. Property damage to roads, irrigation projects, power stations, houses, schools, farm land etc. has been provisionally estimated at about Rs. 4.2 billion which will become even higher when the detailed assessment will be completed.

In view of such an extensive damage by the disaster, HMG/Nepal is seriously considering to establish a comprehensive programme of disaster prevention and preparedness comprising variety of non-structural and structural measures. Flood warning and evacuation system for flood prone areas is one of the most important components of the programme.

Among a number of flood prone areas in the country, priority has been given to downstream areas of the Bagmati river and East Rapti river, where the casualties were the heaviest during the recent floods.

2. Objective

The objective of this Project is to mitigate flood damage, especially human losses, in the Bagmati and the East Rapti Rivers by introducing the flood warning and evacuation system consisting of the flood warning network and the construction of elevated mounds and water-proofed structures.

3. Outline of the Project

(1) The proposed flood warning system intends to issue warnings to the local people exposed to flood threats by collecting prior information from the stream and rain gauges installed in the upper reaches. The installation of this system includes the following works:

- Establishment of six new stream gauges; 30, 20 and 10 km upstream of the irrigation barrage for the Bagmati River and 30, 20 and 10 km upstream of the confluence with the Lothar River for the East Rapti River,

- Establishment of the radio communication system (VHF) between the stream gauges and the key communication station,

- Establishment of a key communication station at the Bagmati irrigation barrage site, and

- Establishment of a flood warning issuance system by telephone to the flood-prone areas; 15 VDCs for the Bagmali River basin and 7 VDCs for the East Rapti River basin. These numbers are still to be determined in consultation with local offices later.

(2) The flood evacuation facilities will be composed of water-proof structures and elevated mounds (for cattle etc.), strategic sites with necessary capacities. The precise locations of the sites are still to be determined in consultation with local people, but the number is provisionally given as in (1) above. These structures will be used for multi-purposes such as shelter cum school etc.

4. Benefits, Effects and Publicity of the Project

Beneficiaries of the projects are all the people living in the flood-prone areas of the Bagmati and East Rapti Rivers. Thus, the project is in fact the works towards the public interest. Furthermore, the benefits and effects of the project are invaluable due to the fact that its main purpose is to save human lives from flood threats.

5. Ministry and Agency in charge of the Project

The Department of Hydrology and Meteorology, Ministry of Water Resources, is in charge of implementing the project, in cooperation with Department of Irrigation of Ministry of Water Resources, Ministry of Home and Ministry of Local Development.

THE NATIONAL HYDROLOGICAL DATA IMPROVEMENT PROJECT

TERMS OF REFERENCE

(Draft)

THE NATIONAL HYDROLOGICAL DATA IMPROVEMENT PROJECT

Economic Sector Hydrology and Meteorology	Project Type: [*] 1. Facilities Construction [*] 2. Equipment Supply
Total Project Cost	Japanese Yen 1,200,000,000 (Y 420,000,000 in the First Stage) (Y 780,000,000 in the Second, Stage)
Responsible Ministry (Ministry requesting the aid) Ministry of Water Resources (MOWR)	Implementing Agency (Agency in charge of execution of the Project) Department of Hydrology and Meteorology (DHM)

1. Project Description

1. Background (Please describe in detail)

(1) Current Situation of the Sector

Continuous and reliable data is prerequisite for proper planning/designing of development projects (water resources development etc.), disaster prevention projects (against floods, debris flows, landslides etc.) and so on. The first rainfall station was established in 1921 in the Indian Embassy in Kathmandu (for monthly observation), but it is only a couple of decades ago when hydro-meteorological observation commenced for such purpose. The DHM was recognized in 1987 to expedite improvement. However, there are still many problems as mentioned in (2) below. The existing raingauqes and water level gauges operated by the DHM are 266 (580 km^2/observatory) and 135 respectively. The observed data are processed by personal computers and disseminated.

(2) Problems to be solved in the Sector

Despite the effort, density of observations is insufficient, the observation intermittent, data quality is insufficient, and data processing/management works are irregular and non systematic due to (a) lack of skilled technical personnel, (b) inadequate procedure of activities, (c) difficult and transportation, and (d) budgetary constraint.

(3) Necessity and Importance of Improvement in the Sector which lead to the formulation of the project

The heavy rains on 19-21 July 1993 resulted in an unprecedented disaster in many parts of Nepal, especially in Central Region: with the magnitude of floods far exceeding the design discharge, barrages, embankments, bridges, etc. were seriously damaged; some villages were washed away when villagers were not aware of the impending danger because the rains there were not so heavy.

The problem now encountered is the lack of sufficient data necessary for proper plan/design of reconstruction of such major infrastructures and flood control projects.

The heavy rains of July disaster concentrated in mid-Nepal but similar phenomena may occur at any place in the country.

Thus, the disaster event clearly indicates the necessity of improving hydrological and meteorological data collection and processing/analysis as well and it is imperative for HMG to initiate actions to this effect.

(4) Relation between the sector and the Project

The proposed Project is formulated in line with policies of the HMG/N in the hydrology and meteorology sector collect and analyse data relating to hydro-meteorology. The Project will contribute to other sectors such as flood control and warning, hydropower, road construction, agriculture and rural/urban development, to which high priority is given in the national development plan, by supplying reliable hydrological data to them.

2. Objectives and Outline of the Project

(1) Objectives of the Project

(i) Short-term Objectives:

to improve quality of the hydrological data, quantitatively and qualitatively, by strengthening the existing hydrological observation network and data management system of the DHM.

(ii) Medium and Long-Term Objectives:

to observe and manage nationwide, long term and reliable data which are useful for and ensure analysis of hydrometeorological characteristics in the whole country, evaluation of national water resources, planning of the water resources development projects comprising hydropower, irrigation, water supply, flood control and watershed management and management of river discharge.

(iii) Please fully describe the relation between the project and objectives, and how the project will contribute to the accomplishment of the objectives.

to attain the above objectives, the principle aims are:

(a) to improve operational activities of hydrological observation stations and sediment laboratories by repairing existing observation/analysis equipment facility, introducing basic hydrological stations and reviewing manuals of observation and analysis with instruction,

(b) to improve maintenance activities of the stations and the laboratories by establishing a current meter calibration facility, reinforcing equipment workshop and reviewing manuals of establishment, inspection and maintenance.

(c) to improve data processing and management activities by strengthening computer and other equipment and reviewing manuals of data collection, processing, storing and dissemination,

(d) to improve capability to increase data reliability by establishing a training centre, training staff, and activise data quality research work with manual and instruction, and

(e) to improve monitoring and evaluation works of all the activities in the DHM by applying and modifying manuals with instruction

(2) Outline of the Project (Please give a full description of each facility and equipment and their detailed specifications)

(a) repair/installation of 82 ordinary raingauges and 14 recording raingauges

(b) repair/installation of 20 staff gauges and recording water level gauges

(c) repair/installation of 28 cableways and provision of 25 current meters

(d) provision of 14 sediment samplers and 11 turbidity meters

(e) provision of sieves, hydrometers, ovens and balances of sediment laboratories

(f) provision of tools and equipment of a workshop

(g) establishment of a current calibration facility

(h) provision of 10 sets of computers, their accessories, softwares and furniture

(i) establishment of a training centre with 4 sets of computers and furniture

(j) review of manual and instruction for all the DHM activities

It is noted that item (i), establishment of a training centre with 4 sets of computers and furniture, will be implemented as the Second Stage of the project.

(3) Location Plan of each Facility and/or Equipment

(a) Observation equipment will be distributed in the whole country.

(b) Equipment for sediment analysis will be installed in 4 DHM regional offices. Tools for the workshop will be reinforced in the DHM central office.

(c) The calibration facility, training centre, and computer equipment and accessories will be provided in the DHM central office in Kathmandu.

(4) Cost Estimates (Please describe in detail all the premises on which the cost estimates are based such as basic unit prices, inflation rate, foreign exchange rate, and so on. Please attach detailed tables of estimated costs of each facility and item of equipment. If estimated in local currency, please mention the latest exchange rate of the currency to the U.S. dollar or the Japanese yen.).

Premise for cost estimate is as follows:

(a) Unit costs of respective works are estimated at a price level as of February 1993 (US$ 1.00 = NRs. 46.4315 = J yen 121.05).

(b) Taxes and duties on construction materials and equipment to be imported from abroad are to be exempted.

The estimated total project cost is Japanese Yen 1,200,000,000, of which the First Stage requires Japanese Yen 810,000,000 and the Second Stage needs Japanese Yen 390,000,000. The estimated costs for respective works are itemized as below.

		Total	1st Stage	2nd Stage
(a)	observation instrument and station	184,000,000	184,000,000	–
(b)	equipment of laboratory and workshop	6,100,000	6,100,000	–
(c)	current meter calibration facility	72,300,000	–	72,300,000
(d)	training centre	358,800,000	–	358,800,000
(e)	computer equipment and accessories	41,500,000	41,500,000	–
(f)	engineering and administration	374,000,000	132,000,000	243,000,000
(g)	price escalation and contingencies	162,300,000	56,400,000	105,900,000
	Total	1,200,000,000	420,000,000	780,000,000

3. Benefit, Effect and Publicity of the Project

(1) Population that will benefit directly from the Project
all the governmental/private users of hydrological data

(2) Population that will benefit indirectly from the Project
all the persons who utilize water developed by projects or live in areas which were water induced disaster areas and improved by projects.

(3) Areas that will benefit: from the Project
the area in the whole country where the above people live.

(4) Economic and Social Effects of the Project (Please describe in detail)

(i) Current situation
The Hydrological observation is intermittent, data quality is insufficient, and data processing/management works are irregular and non systematic due to several adverse factors.

(ii) Expected Effect of the Project

The Project will enable to observe reliable hydrological data and will expedite to observe continuous data, which will induce effective, economical and realistic planning and designing of water resources development projects and will accelerate them to be implemented.

(5) Publicity (How many people are expected to notice the benefit or positive effect of the project implemented with Japan'S grant aid when it is completed?).

all the persons who utilize water developed by projects or live in areas which were water induced disaster areas and improved by projects.

4. Request to Other Donors

(1) Is there any request made to other donors for assistance closely related to this project?

[ ] 1. Yes [*] 2. No

(2) If yes, please fill in below:

(i) Name of the donors;

(ii) Title and outline of the assistance;

(iii) Possibilities that the donor will extend the assistance requested;

(iv) In the case where other donors do not extend assistance, please describe in detail appropriateness and effectiveness of this project;

This Project aims to raise capability of the hydrometeorological observation and data management by a combination of facility construction, equipment supply and instruction of operation and maintenance in the regions and the central office. The facility construction and equipment supply are urgently required for improvement of the hydrological data.

(v) In the case where other donors extend loans, please describe the reason why Japan's Grant Aid is requested for the project.

N.A.

5. Priority

(Please describe priority of this project among other projects are made to Japan.).

The HMG/N has given highest priority to the implementation of the Project.

(Please attach project list with priorities)

6. Ministry and Agency in charge of the Project

(1) Outline of Implementing Agency (Please describe in detail) (the Agency in charge of the execution of the Project)

The implementing agency is the Department of Hydrology and Meteorology (DHM). The DHM is one of the Departments under the Ministry of Water Resources.

(i) Organization Chart of the Agency (in general)
(Please mark the responsible department and division in charge of the project)
See Attachment-1

(ii) Authorities and Duties of the Agency
The DHM is responsible to fulfill the role of observation, management, analysis and dissemination of hydrological and meteorological data including forecasting and other data/information.

(iii) Personnel (please mention the number of staff, workers, and employees of the agency and the responsible department, division and section in charge of the project)

(for the central office only in 1992)	Agency	Division
Senior Officer/Hydrologist/Meteorologist	22	6
Officer/Hydrologist/Meteorologist	49	11
Technician/Office Staff	92	16
Total	163	33

(iv) Budget (Revenue and Expenditure)
(If mentioned in local currency, please mention the latest foreign exchange rate of the currency to the U.S. dollar or the Japanese yen)

(a) budget of the DHM in fiscal year of 1992/1993: NRs. 26,984,000

(b) exchange rate in December 1992: 1 US$ = 46.71 NRs

(2) Outline of Supervising Ministry (Please describe in detail)
The Supervising Ministry is the Ministry of Water Resources (MOWR), under which the DHM is functioned.

(i) Organization Chart of the Ministry (in general)
(Please mark the responsible department and division in charge of the project and implementing agency)
See Attachment-2
(Please attach detailed organization chart pointing out the responsible department, division and sections in charge of the project and implementing agency)

(ii) Authorities and duties of the Ministry
The MOWR has the sole responsibilities for planning, implementation and management of water resources development of the country.

(iii) Personnel (Please mention the number of staff, workers and employees of the Ministry and the responsible department, division and section)
See Attachment-3

(iv) Budget (Revenue and Expenditure)
(If mentioned local currency, please state the latest foreign rate of the currency to the dollar or the Japanese yen)

(a) budget of the in fiscal year of 1992/93: NRs. 5,263,000
(for administrative purpose only)

(b) exchange rate in December 1992: 1 US$ = 46.71 NRs

7. Preparation

(1) Protect site (Please attach photographs maps of the sites with the various scales including that of 10,000:1)

(i) (a) address of the site
Observation equipment will be distributed in the whole country. Equipment for sediment analysis will be installed in DHM regional offices. The calibration facility, tools for the workshop, training centre, and computer equipment and accessories will be provided in the DHM central office.

(b) Total areas of the Site
5,000 m^2 for calibration facility and training centre. (Most observation equipments can be installed in the Government land. The other equipment will be installed in the existing buildings.).

(ii) Land Preparation

(a) To which extent has the land been expropriated for the project? Partially

(b) When will be expropriation of the land be completed?
Land will be expropriated as soon as the Basic Design of the Project is started.
(Please attach the laws and procedures concerning the expropriation of land.)

(2) Electricity, Water Supply, Telephone, Drainage and other Facilities
(please describe the extent to which above mentioned incidental facilities have been prepared)
The DHM has all these facilities at present.

(3) Is there any information, statistics and data regarding geographical, geological, meteorological, oceanographical situations, etc.
(If any, please attach those information)

8. Capabilities of the Implementing Agency
(please describe the capabilities of the agency to manager sustain, and operate the project.)

(1) Current Situation
The Agency (DHM) been successfully managing, sustaining, and operating such projects as the UNDP project and Snow and Glacier Hydrology Project. Through these project operation, the Agency has accumulated experiences and know-hows, which would be applicable to this project.

(2) Problems of the Agency
Shortage of skilled technical staff, and budgetary constraint.

(3) Improvement Plan (If any, please describe in detail the contents of such a plan that will enable the Agency to handle the project more effectively and efficiently.)
In order to handle the Project more efficiently, it is desirable to assign foreign experts in operation stage of the project and to provide key local staff with overseas trainings.

9. Operation and Management of the Project

(1) Personnel (Please fill in the numbers of personnel.)

	Current	When the Project is completed
Supervising Ministry	106	–
Implementing Agency	163	–
Directly Responsible Personnel (State enterprise for Design & Survey)	33	–

(In the case of hospital, research institutes, training centers, please attach the functional personnel charts.)

(In the case where necessary personnel are not yet secured, when and how this is to be done)

(2) Budget (Please fill in the below table)

(If mentioned in local currency, please refer to the latest foreign exchange rate of the currency to the US dollar of Japanese Yen)

(Units: NRs)

	2 years ago (1990/91)	1 year ago (1991/92)	now (1992/93)	when the project will be completed
Supervising Ministry (for administration purpose only)	1773000	2377000	5263000	–
Implementing Agency	18688000	21837000	26984000	–
Direct budget of the project	–	–	–	–

(In the case where additional budgetary allocation for the implementation of the project, please answer the following question.)

(i) Has the additional budget been already allocated?

[ ] 1. Yes [*] 2. No

(ii) If no, how and when will the additional budget be allocated?
Additional budget will be obtained as soon as the Japanese assistance to the Project is approved.

(3) Technical Abilities of Local Staff

(i) Please describe technical abilities of local staff operating the project.
The Staff of the Implementing Agency are relatively accustomed to the routine operation of the existing system. However, systematic training is needed to raise the technical level of the staff.

(ii) Please describe in detail educational background of those who are in charge of the operation and management of the facilities and equipment.
Six senior or divisional Hydrologists are Master of Engineering. The other several Hydrologists are Bachelor.

10. List of- Related Projects

(Please fill in below if there is a project executed by another donor country or international organization in related areas.)

(1)	Name of donor	united Nations Development Programme
(2)	Project Title	development of Operational Hydrology Services
(3)	Project Outline	repair of river gauges, introduction of computers and data bank, publication of year books, provision of workshop facilities, and staff training
(4)	Type of Assistance (grant, loan, technical assistant, etc.)	grant and technical assistance
(5)	Project Period	1982 to 1987
(6)	Relation with this Project	further improvement by this Project of the existing system which was rectified by the above project. (If there are many projects, please attach a list of those explained in the same way)

11. Technical Assistance

(1) Has technical assistance been extended to this project?

[*] 1. Yes [ ] 2. No

(2) Is technical assistance needed for the implementation of this project?

[*] 1. Yes [ ] 2. No

(3) Is no, please describe the reasons why technical assistance is not needed.

(4) If yes, please fill in below.

(i) Short-term experts

(ii) Long-term experts : an observation expert and a computer expert

(iii) Acceptance of trainees : five trainees on observation and data management

(iv) Project-type Technical Cooperation
(If needed, please describe the proposed project outline.)
It is hoped that the Water Induced Disaster Prevention Technical Centre (DPTC), which is Japan's project-type technical cooperation, will provide technical assistance to the project.

(v) Japan Overseas Cooperation Volunteers
(If needed, please describe the proposed sector and related information.)

(vi) Development Survey Programme (Feasibility Studies; and Master Plan)
(If needed, please describe the outline of the proposed development survey programme.)
Master Plan and Feasibility Study are being conducted with the technical cooperation of the Japan International Cooperation Agency.

(5) Has an official request for technical assistance already made?

[ ] 1. Yes [*] 2. No

(iii) If yes, please mention the date of the request.

(iv) If no, please describe the reason why the official request has not been made.
The scope of the Project works to be implemented under the Japanese Aid is not yet fixed.

(v) When will the request be made to the Embassy of Japan?
An official request will be made as soon as the Basic design of the Project is completed.

II. General Development Plan

1. Title of the plan

(Please attach the whole volume of the latest general development plan.)
EIGHTH PLAN (1992-1997)

2. Economic and Social Situation

(Please mention the basic statistics of economic-fundamentals.)

(1) GNP
(NRs. 89,941 million at current price in 1989/90)

(2) National Income, Sector by Sector

Gross Domestic Product	:	NRs. 88,771 million at current price in 1989/90
Agriculture	:	NRs. 50,032 million at current price in 1989/90
Non-agriculture	:	NRs. 38,679 million at current price in 1989/90

(3) Unemployment Rate
N.A.

(4) Inflation Rate
National urban consumer price index (base year: 1983/84 = 100)

	1988/89	1989/90	1990/91
Food	165.9	181.9	200.4
Non food and services	153.7	177.2	193.4

(5) Growth Rate

GDP at 1974/75 price in 1989/89	NRs. 28,536 million
GDP at 1974/75 price in 1989/90	NRs. 29,560 million (growth rate = 3.6%)
GDP at 1974/75 price in 1990/91	NRs. 30,745 million (growth rate = 4.0%)

(6) Balance of international payments
NRs. 7,754 million deficit in 1989/90.

(7) Labour Population (as a whole, and sector by sector)

Economically active population in 1981	6,850,886
Agriculture, Forestry and Fishing	6,244,289
Manufacturing	33,029
Others such as mining, construction	573,568

(8) Debt Service Ratio

10.8% in 1988

(9) Outstanding Debts

US$ 1,088 million in 1988

(10) Major Items of Export- and Imports and their value

Export (1989/90)	NRs.	5,156 million
Manufactured goods	NRs.	2,693 million
Miscellaneous manufactured article	NRs.	1,573 million
Food and live animals	NRs.	616 million
Crude materials, inedibles except fuels	NRs.	239 million
Others	NRs.	35 million
Import (1989/90)	NRs.	18,325 million
Manufactured goods	NRs.	5,065 million
Machinery and Transport equipment	NRs.	3,790 million
Chemicals and drugs	NRs.	2,824 million
Food and live animals	NRs.	1,608 million
Crude materials, inedibles except fuels	NRs.	1,571 million
Others	NRs.	3,467 million

(11) Major Trading Partner

Exports (1987/88): India, U.S.A., Germany F.R., United Kingdom

Imports (1987/88): India, Japan, Singapore, Germany F.R., Korea R.

(12) Population and its Growth Rate

Population in 1991	18,462 thousand
Annual average growth rate 1981-1991	2.08%

(13) Average Life Expectancy (Male and Female)

54.88 for male in 1989

52.10 for female in 1989

53.52 for both in 1989

(14) Death Rate and Birth Rate

Death per 1000 population in 1986/87	:	16.00
Birth per 1000 population in 1986/87	:	41.00

(15) Medical Structure

Total number of hospitals in 1990/91	:	111
Total number of hospital beds in 1990/91	:	4,768
Total number of doctors in 1990/91	:	1,196

(16) Ten Diseases most afflicting the nation

N.A.

(17) Illiteracy Rate for literacy Rate)

N.A.

(18) Other data

3. Outline of the Plan

(1) Most Important Sectors in the Plan

Water resources development such as irrigation and agriculture, energy, water supply for industry and urban/rural development

(2) Basic Objectives of the Plan

(Please describe in detail the objectives by using concrete figures.)

(a) sustainable economic growth with the rate of 5.1%; (b) alleviation od poverty; and (c) reduction of regional imbalances

(3) How will the above-mentioned objectives be achieved?

The objectives will be attained by (a) agriculture intensification and diversification, (b) energy development, (c) development of rural infrastructures, (d) employment generation and human resources development, (e) reduction in population growth, (f) industry and tourism development. (g) expert promotion and diversification, (h) macro-economic stabilization. (i) administration reform, and (j) monitoring and evaluation.

4. When will the plan be executed and completed?

The Plan was started in July 1992 and will be completed in June 1997.

5. **Relation between this project and the general development plan.**
(Please describe the significance of the project in the general plan.)
The general plan gives high priority to water resources development of the country. The Project will contribute to effective and economical planning of the water resources development by providing reliable hydrological data.

6. **Is there any assistance that donors have extended to the projects and/or programme listed in the general plan?**

[*] 1. Yes [ ] 2. No

(iii) If yes, please give basic information on the assistance.

(a) Name of donor
Federal Republic of Germany

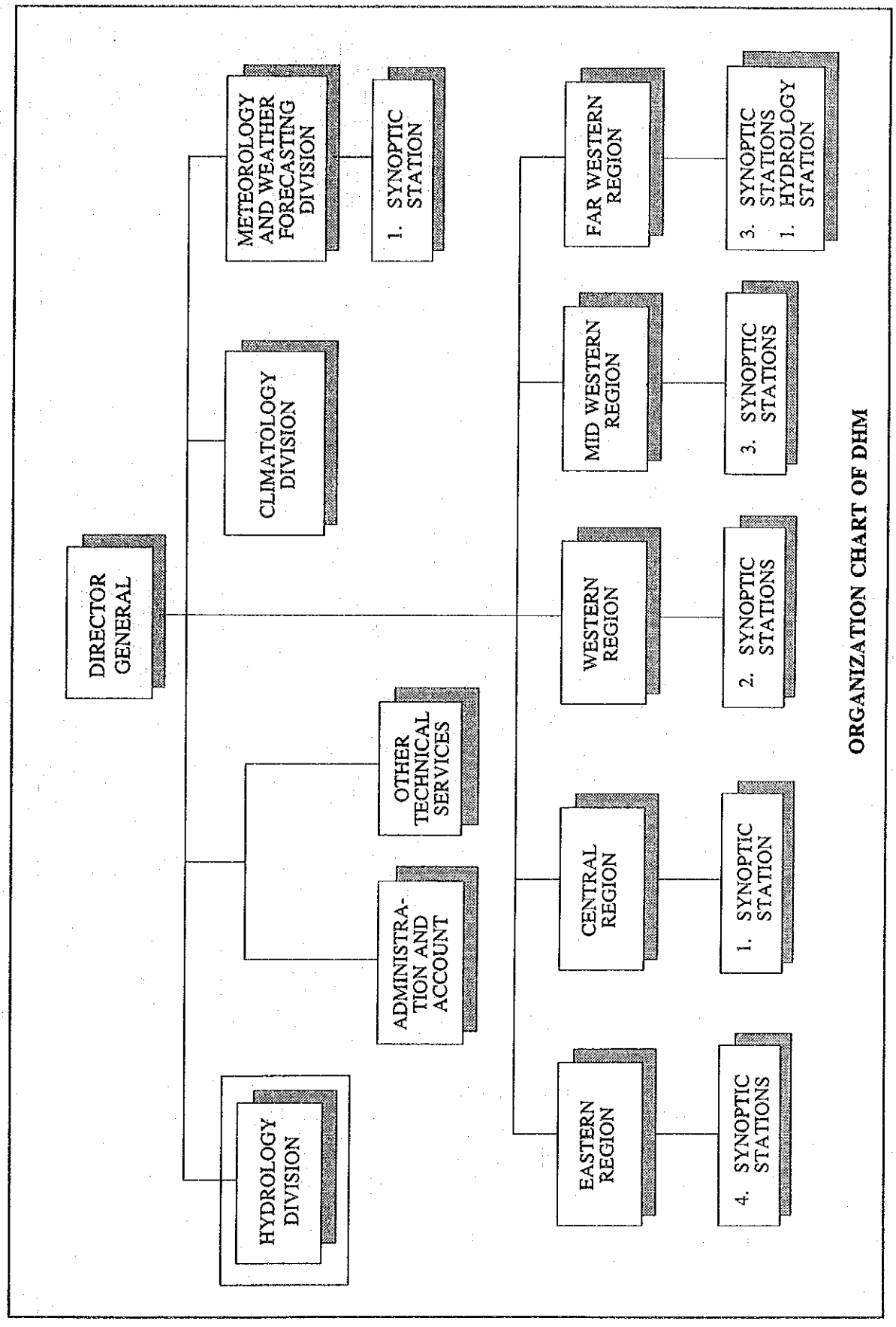
(b) Project Title
Snow and Glacier Hydrology Project

(c) Project Cost:

(d) Type of Assistance (Grant, Loan, Technical Assistance, etc.)

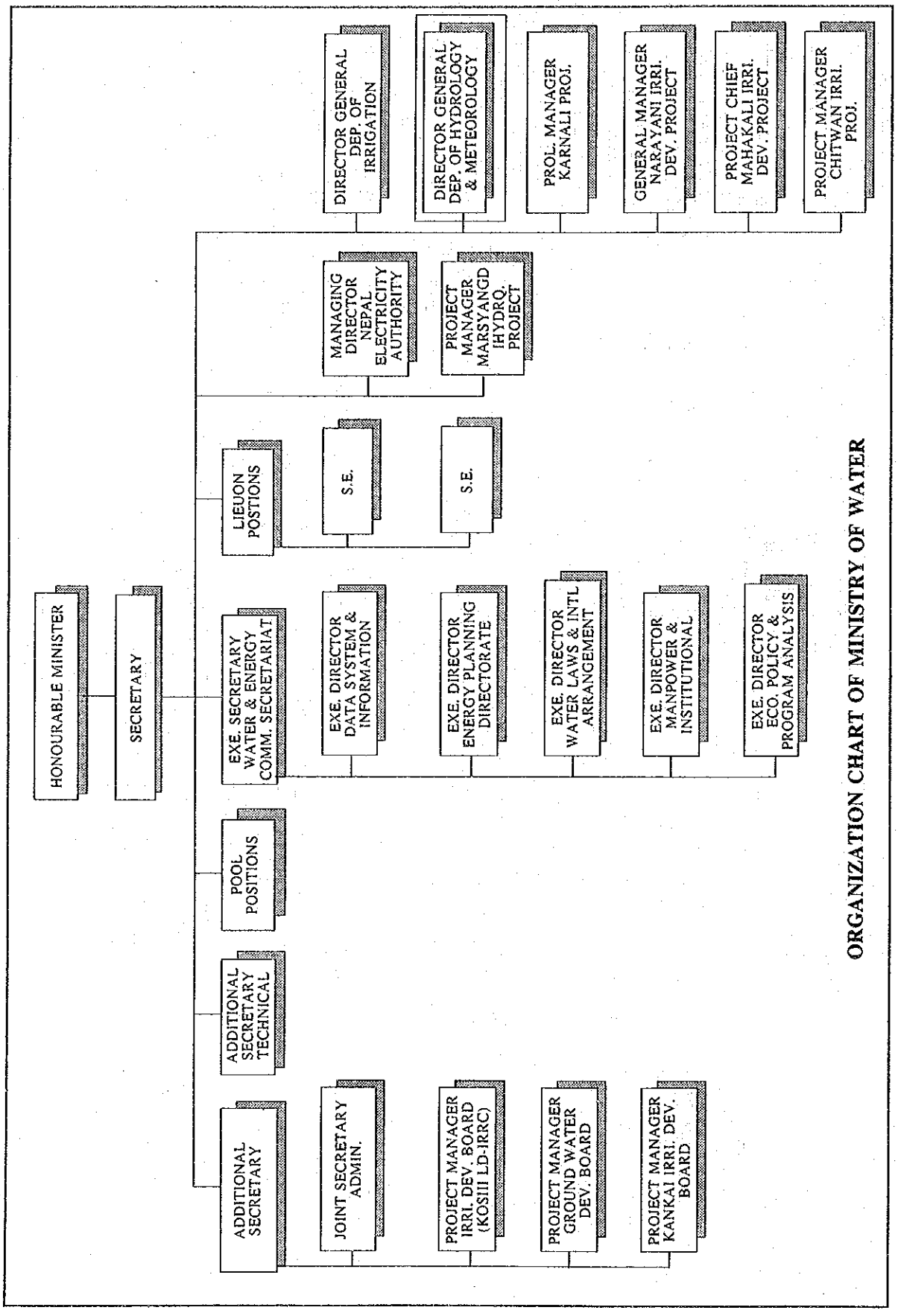
(e) Project Outline
The project was initiated in 1987. The objective of this pilot project is to establish six hydrometeorological stations in snow and glacier regions of Nepal Himalaya to collect data relevant to water resources planning.

Attachment-1



ORGANIZATION CHART OF DHM

Attachment-2



Attachment-3

Number of Personnel assigned in the different Divisions in the Ministry of Water Resources

1. Office of the Secretary	
a. Secretary	1 no.
b. Personal Assistants to the Secretary	2 nos.
2. Administrative Division	55 nos.
3. Planning Division	17 nos.
4. Electrical Division	11 nos.
5. Irrigation Division	12 nos.
6. Miscellaneous	8 nos.
Total:	106 nos.

REVIEW OF THE FLOOD MITIGATION MASTER PLANS OF THE BAGMATI, EAST RAPTI AND KAMALA RIVERS

TERMS OF REFERENCE

(Draft)

TERMS OF REFERENCE
FOR
REVIEW OF THE FLOOD MITIGATION MASTER PLANS OF THE BAGMATI, EAST RAPTI AND KAMALA RIVERS

Project Title	:	Review of the Flood Mitigation Master Plans of the Bagmati, East Rapti and Kamala Rivers
Location	:	Flood-prone areas extending along the Bagmati, East Rapti and Kamala Rivers in the territory of Nepal
Executing Agency	:	Ministry of Water Resources

1. Objectives of the Study

The objectives of the Study are (1) to review the existing flood mitigation master plans carried out for the flood-prone areas of the Bagmati, East Rapti and Kamala rivers based on the records of the recent July 1993 flood, and (2) to undertake the feasibility studies for the Kamaiya reaches of the Bagmati River and other priority areas proposed in this review study.

2. Background

Downpours (maximum daily rainfall was 540 mm on 19 July at Tistung) of the 19th to the 21st July 1993 caused extensive and severe damage by floods, debris flow and landslides in various parts of Nepal especially in the Central Region. The disaster was the biggest that Nepal has ever experienced. Many villages were completely washed away by floods or buried by debris flows, claiming human lives of 2,155 persons including 1,000 missing. Property damage to roads, irrigation projects power stations, houses, schools, farmlands etc. has been provisionally estimated at Rs. 4.2 billion which will become higher when the detailed damage assessment will be completed.

Most seriously affected by floods were downstream areas of the Bagamti, the East Rapti and the Kamala rivers. Flood mitigation master plans for Bagmati and Kamala rivers were prepared in 1992 by the point team of Nepal and India with the project title of "Extension of Embankments along the Bagmati, River" and "Extension of Embankments along the Kamala Rivers". On the other hand, river bank protection works of the East Gapti River were studied in 1989 as part of the East Rapti Irrigation Project.

The July 1993 flood, which caused extensive damage by discharge exceeding the design discharge, inevitably seeks the review of the flood mitigation master plans so prepared for the said three rivers. The feasibility studies of flood mitigation are needed to be undertaken for the Kamaiya reaches of the Bagmati River and other priority areas identified in this review study as soon as possible, taking into consideration the fact that the areas critically susceptible to floods are to be protected immediately.

3. Study Areas

The Study covers the following flood-prone areas:

- 54 km long river stretches between the irrigation barrage and the international border with India for the Bagmati River,

- 35 km long river stretches between the East-West Highway bridge and the international border with India for the Kamala River, and

- 30 km long river stretches between the confluences with the Lothar River and the Khageri Khola for the East Rapti River.

4. Scope of Work

The Study will be divided into three stages, i.e. Preparatory Work Stage, Field Work Stage and Review and Feasibility Study Stage. Each Stage includes the following study items (refer to Figure 1):

A. Preparatory Work Stage

(1) Review of existing master plan studies

This task includes the review of study reports on the flood mitigation carried out in the study areas.

(2) Collection of relevant data and information.

Following data and information will be collected as much as possible:

Topography and geology

- aerophotos and topographic maps
- river longitudinal profiles and cross sections
- data on soil and geological conditions

Hydrology and meteorology

- rainfall
- flood runoff; flow discharge and hydrographs at the existing stream gauges
- sediment data

Flood damage

- records of past floods including flood areas damage
- planned/on-going flood mitigation projects

Facilities and management

- existing river and relevant structures
- irrigation and drainage facilities including diversion weirs
- operation and maintenance records of the above structures/facilities

Land use

- land use map and vegetation map
- land use plan

Socio-economic condition

- population distribution and its growth rate
- existing development projects and plans

(3) Field reconnaissance

Field reconnaissance will be carried out to clearly demarcate the study area in reference to collected data and information, and to identify the areas and places where field surveys are executed.

(4) preparatory Work of Field Surveys

Technical specifications for the terrestrial topographic surveys and the photogrammetric mapping will be prepared.

B. Field Work Stage

(1) preparation of longitudinal profiles and cross sections

The river cross section will be prepared with an interval of 200 m for the 4 km long Karmaiya river stretches of the Bagmati River, whilst 500 m interval for the East Rapti and Kamala rivers and the remaining part of the Bagmati River.

(2) Photogrammetric mapping

Topographic maps with a scale of 1 to 10,000 will be prepared for the project areas using existing 1 to 40,000 scale aerial photographs.

(3) Soil/geological survey

Soil/geological survey will be carried out at the proposed structure sites, and furthermore potential quarries and borrow areas will be identified to acquire construction materials.

(4) Meteo-hydrological measurements

Intensive meteo-hydrological measurements will be carried out through the course of the study.

(5) Interview survey for flood damage

The areas damaged by the past floods will be identified, and furthermore, the magnitude of damage will be surveyed through interviews to local people.

(6) Environmental survey

Negative impacts to be caused by the implementation of the project such as displacement of local people will be discussed, and the compensating measures for them will be proposed.

C. Review and Feasibility Study Stage

(1) Hydrological and hydraulic analysis

- Prediction of probable peak discharge
- Estimates of river flow capacity

(2) Flood damage analysis

- classification of assets and economic activities to be damaged by floods in the study area
- preparation of an inundation map indicating the flood-prone areas
- estimates of flood damage by scale
- evaluation of flood damage impacts to the economic and social activities

(3) Karmaiya feasibility study

Following work will be carried out for assessing the economic viability of the Karmaiya scheme:

- Feasibility design of the structures proposed for the scheme
- Estimates of project costs
- Preparation of construction plan
- Examination of economic viability for the project
- Overall assessment of the project taking into consideration the social and environmental impacts.

(4) Review of the existing master plan studies

The existing flood mitigation master plans proposed for the Bagmati, Kamala and East Rapti rivers will be reviewed based on the records of July 1993 flood and the newly prepared topographic maps and river profiles.

(5) Selection of priority areas

The priority areas to be protected from flooding will be proposed on the basis of the review results of the existing flood mitigation master plan studies.

(6) Feasibility studies for the selected priority areas

Study items proposed for the Karmaiya feasibility study (as mentioned in (3) above) will be dealt with for the selected priority areas as well.

5. Institutional Aspects

The executing agency of the study is the Ministry of Water Resources HMG Nepal. The Nepal expects technical assistance from the Government of Japan in implementing this study.

Counterpart personnel and logistic support will be provided to the necessary extent by the executing agency, and coordination and cooperation with the agencies concerned will be arranged through the executing agency.

6. Work Schedule and Reports

The Study will require a time period of 14 months as given in Figure 1. Through the course of the study, following reports will be prepared:

(1) "Inception Report" within 2 months after the commencement of the study, describing a summary on the objective of the study, initial findings and a detailed plan on the operation and methodology of the study.

(2) "Progress Report" within 4 months after the commencement of the study, dealing with the current situation of flooding in the project area and the results of field surveys.

(3) "Karmaiya Feasibility Study Report" within 7 months after the commencement of the study, discussing the economic and social viability of the Karmaiya flood mitigation project.

(4) "Interim Report" within 10 months after the commencement of the study, giving the review of the existing flood mitigation master plan studied and selecting the priority areas to be protected against floods.

(5) "Draft Final Report" within 12.5 months after the commencement of the study, describing the results of feasibility study for the selected priority areas.

(6) "Final Report" within 14 months after the commencement of the study, reflecting the comments and suggestions to the Draft Final Report raised by HMG Nepal.

7. Input Requirements

Experts

The study is expected to be undertaken by a team of foreign experts in cooperation with the Ministry of Water Resources. Foreign experts to be required for the study are as follows:

(1) Team Leader
(2) Flood Mitigation Planner
(3) Hydrologist
(4) River Engineer
(5) Hydraulic Structure Engineer
(6) Soil Engineer/Geologist
(7) Socio-economist
(8) Photogrammetrist
(9) Topographic Survey Experts
(10) Environmental Expert
(11) Cost Estimate/Construction Plan Expert
(12) Project Economist

8. Transfer of Technology

Transfer of technology and training will be made in the following manner to the counterpart personnel during the course of the study:

- on-the-job training through the execution of the necessary survey, investigation and analysis, and
- training in Japan to obtain wider knowledge on survey, analysis and planning methods related to the study.

5. Findings and Recommendations of Irrigation Expert Team

5.1 East Rapti River Irrigation Project

5.1.1 Damages condition

- Affected command area is 5,951 ha out of 9,500 ha.
- Intake facilities and agricultural land were affected.
- Three intake facilities (pipe culverts) on the breached portion of the right embankment in Piple V.D.C were washed away and this phenomenon is as illustrated in [Fig. 5.1]
- The number of the intakes of something affected and completely washed away are as follows:

	Affected	Completely washed away	Total area
East Rapti River	10 NOS	6 NOS	2,500 ha.
Budhi Rapti River	15 "	10 "	1,331 ha.
Dhongre River	26 "	18 "	2,120 ha.
Total	51 NOS	34 NOS	5,951 ha.

The kind of typical intake facilities of Farmers Managed Irrigation System (F.M.I.S.) of East Rapti Irrigation Project are aqueduct, box culvert and pipe culvert.

5.1.2 Proposal for emergency reconstruction work

- Relocation of the breached portion of embankment.
- Breached embankment should be aligned with the remained portion of the embankment and three facilities which are located on the breached embankment and other three facilities remained should be brought together into one irrigation system. The structure of the new intake will be box culvert, and tentative head works which could be combination of timber, boulder, and some kind of leaves. [Fig. 5.1]
- Tentative head works might be easily broken, but it is easily reconstructed to be corresponding to change of water route.
- Location of the new intake should be comparatively up stream of the present system as much as possible to secure necessary elevation head with considering the head loss forecasted due to seepage and the reduction of cross section by sedimentation.
- The twenty-four intakes washed away on the other two rivers can not be unified because of the differences of each command area. [Fig. 5.1]
- As for the reconstruction of those intakes HMG/N should coordinate to local water users groups/associations to utilize present systems of F.M.I.S. as much as possible.

5.1.3 Future Measures

- As the matter of course, tentative irrigation system will be unstable to intake irrigation water because of the easy change of the river route.
- So it might be necessary to build new irrigation system (i.e. by constructing new head works and intake facility prepared by the Feasibility Study Report in 1986) for stabilizing to take water in near future.

5.2 Bagmati Irrigation Project

5.2.1 Damages condition

(1) Eastern Canal

- Out of 17 km main canal 4 km was affected
- Contents of damages are as follows;

1) Siltation (thickness was about 1 - 1.5 m) [Fig. 5.2]

2) Slope failure, bank cutting by flood pressure and overflow of water [Fig. 5.2]
   - Slope failure is supposed to have been occurred by the backwater of the upper stream of bridges, aqueduct and siphons.

3) Breaching [Fig. 5.3]
   - Some parts of branch canals were also affected.
     The reason appears to be washed away of embankment by flood stream.

4) Failing down of trees on embankment of the Canal.
   - The length of tree root is extremely short (approximately 1 m) compared to the height of trees (approximately 15 m). So it was observed that the embankment of canal were continuously collapsed by falling down of trees.

(2) Western Canal

- Some parts of the main canal near the east-west high way were damaged due to slope failure, the reason seems to be the sudden widening of cross section to have caught the flood pressure.
- From the portion of east-west highway to the portion about 300 m downstream, canal was sedimented with silt and the thickness of 3 m was observed. [Fig. 5.4]
- The middle and the tail portion of BHALDHIYA Branch were washed away.
- Washing away of the river embankments at the junction of siphon.

(3) Bagmati Barrage

- Almost all gates were damaged; tilted, slanted and inclined.
- Some portion of maintenance bridge was damaged. Damages were movement by uplifting and cracking of concrete slab.
- Guide wall and control house were completely collapsed. Furthermore foundation of generator house was extremely erroded. These damages has been caused by overflow of flood water.
- Big timbers (driftwoods) with the length more than 20 m were entangled in gates. It appears that these timbers prevented the flow of flood.

5.2.2 Proposal for emergency reconstruction work of the canals

(1) Slope failure part

- Properly speaking, in the case of less problem of land purchasing embankment could be built newly on back site of the former embankment. But this countermeasure is not economical. So just filling of soil materials on damaged part and revetment of gabion structure to lower slope should be done. (Fig. 5.5)
- In this case, it is more economical to use the silt and gravels deposited in the canals. And if possible the work should be carried out by heavy machinery.

(2) Breaching

- The breached portion should be re-built.

(3) Sedimentation

- Removing the sedimentation by heavy machinery and man-power.

5.2.3 Proposal for emergency restoration work of Bagmati Barrage

(1) Proposal for the future design for other new projects.

- The width of the gate should be widened as much as possible for the purpose of easy flushing of driftwoods. For example, Japanese standard (by Ministry of Agriculture, Forestry and Fisheries) is as follows:

Design high water discharge	Standard width of gate
m^3/s	m
< 500	15
500 – 2000	20
2000 – 4000	30
> 4000	40

- The gate should have facilities to be moved up to the top of the Barrage corresponding to the flood water level higher than design flood water level.
- The amount of sedimentation deposit should be considered safely in design.

We propose the structure of head works should be combination of fixed weir and gated weir such as Kamala Barrage because it is easy for maintenance and control.

(2) Proposal for emergency restoration work of the Barrage

1) Extension of guide rails of gates to the top of piers. [Fig. 5.6]

2) Reconstruction of embankment.

3) Repairing of the system of electricity and machinery in the control house.

4) Reconstruction of guide wall especially on the left bank.

5) Construction of new embankment with gabion structure to protect the erroded portion of the left bank [Fig. 5.7]

6) Removing of driftwoods.

7) Repairing of maintenance bridge.

8) Removing of sedimentation on the up stream and down stream.

* It is definitely necessary to implement the hydraulics model simulation of unsteady flow which can take into consideration of influences of driftwood and sedimentation etc. in order to decide the facilities scale of above 1) to 8).

5.2.4 Proposal for future treatment

1) Strengthening of embankment on up stream and down stream.

2) Construction of retarding basin (settling basin)

3) Examination of constructing flood control dam.

4) Strengthening of afforestation and reforestation

5) Verification of runoff ratio caused by land developments.

6) Setting of critical region for flood (removing of existing houses and restricting of new house building)

7) Establishment of flood warning water level and flood warning system.

8) It is necessary to set up the designed flood discharge in safer side with considering the influences of driftwood, sedimentation etc. at the region where they would have a lot of suffers.

5.3 Kamala Irrigation Project

5.3.1 Damages condition

(1) Canals

- Main canal had thin sediment deposition.
- Main canal itself had no damage because of strengthening by the concrete structure as slope protection.
- Branch canals has damages as follows;

KHAJURI branch	62 points
MAHINATHPUR branch	12 points

Most of the damages were breaching.

(2) Barrage

- Following parts of the barrage were affected.

1) Breaking of concrete block apron on the upperside of left bank.

2) Washing away of some of energy dissipator

3) Gates have minor damages as following numbers:

	Total Gates	Number of Gate damaged
Left side	8	4
Right side	8	3

5.3.2 Proposal for reconstruction and restoration work

(1) Canals

- Same as other projects.

(2) Barrage

- Repairing of damaged parts can be easily done.

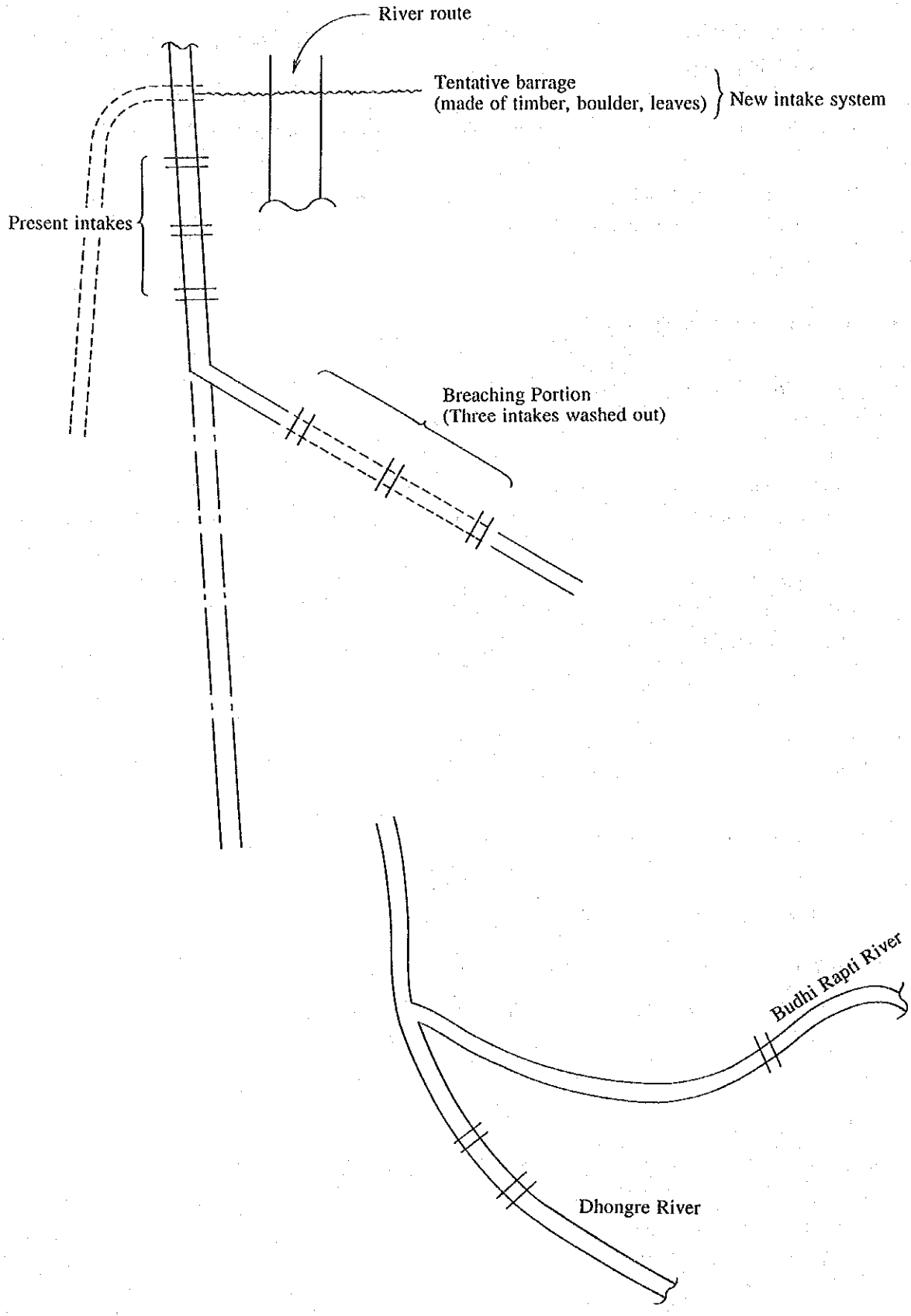


Fig. 5.1 General Map of East Rapti Irrigation Project

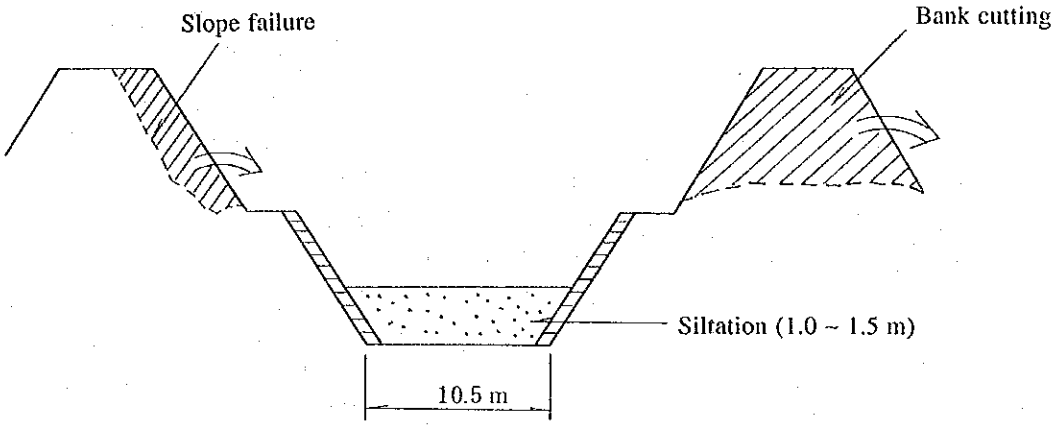


Fig. 5.2 Cross Section of Eastern Main Canal

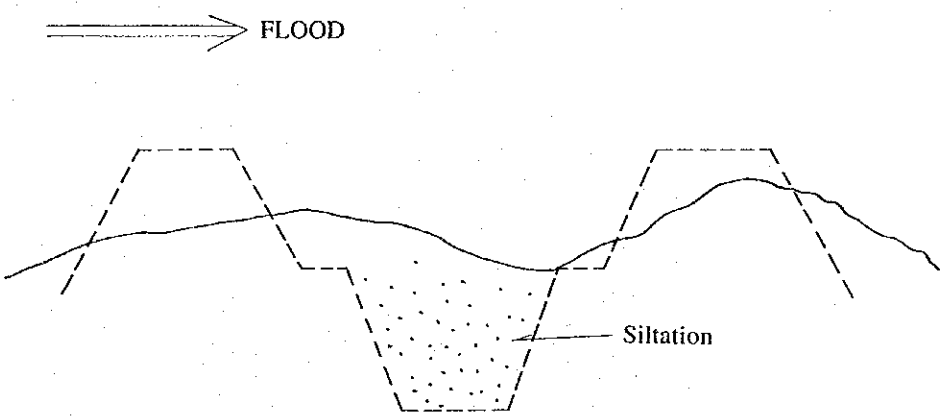


Fig. 5.3 Breached condition

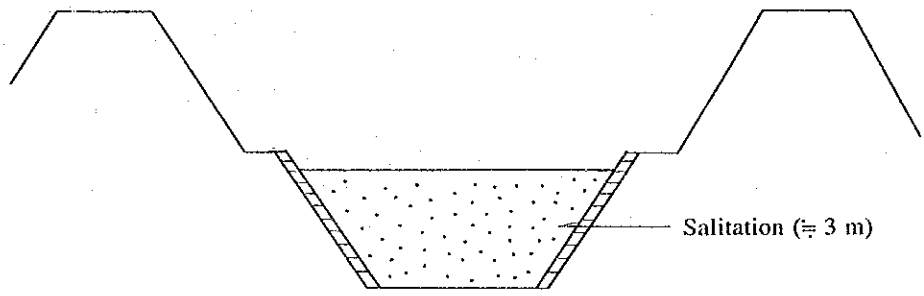


Fig. 5.4 Cross Section of Western Main Canal

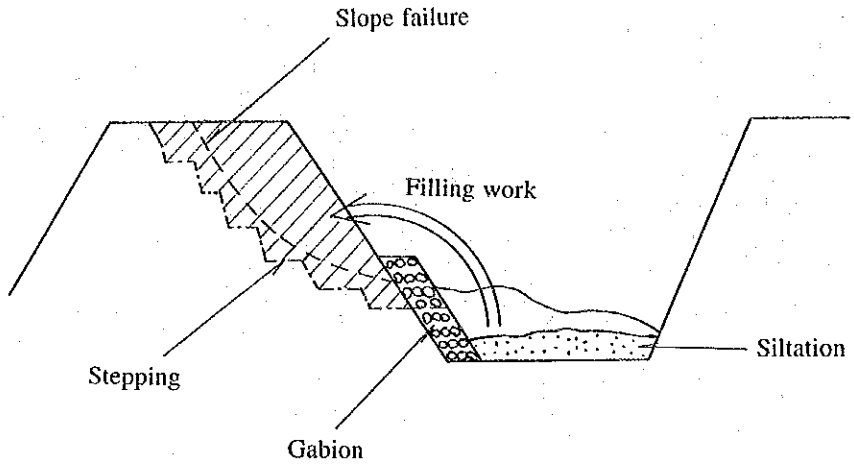


Fig. 5.5 Reconstruction Way of Cannal

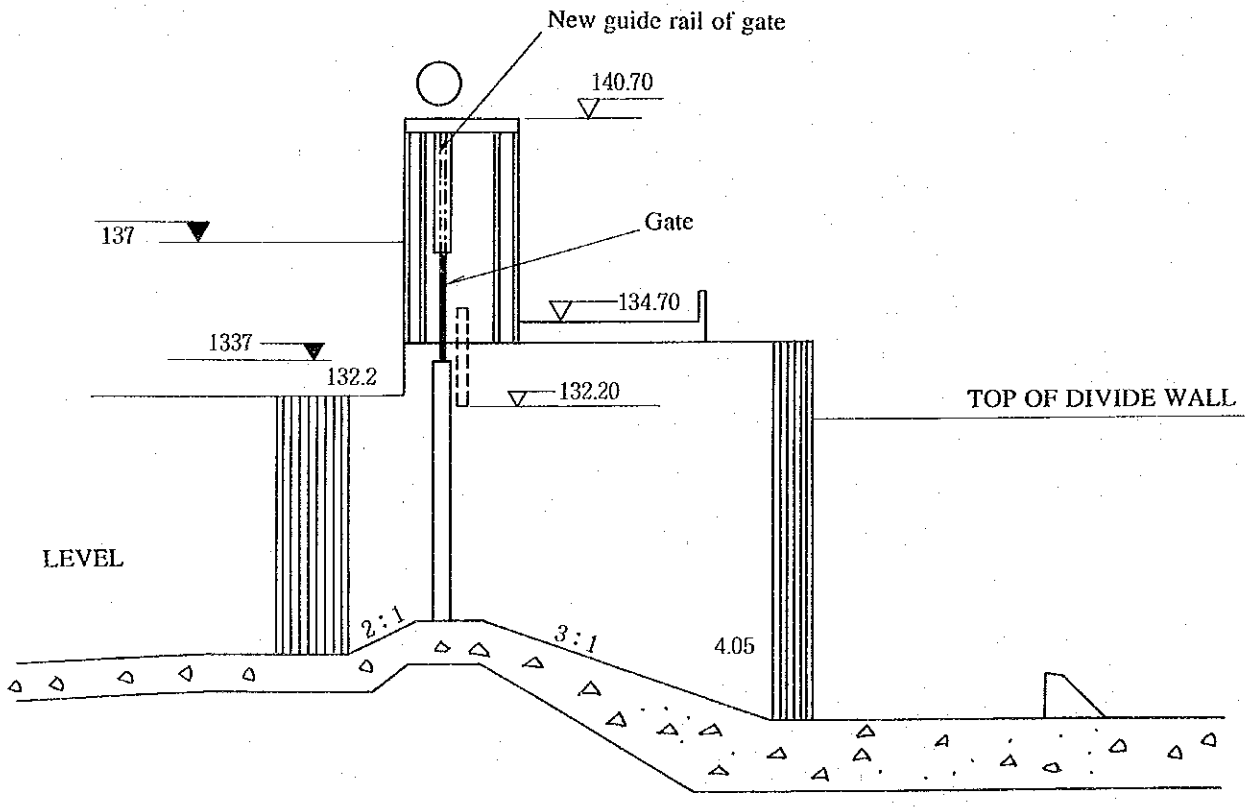


Fig. 5.6 Cross Section of Bagmati Barrage

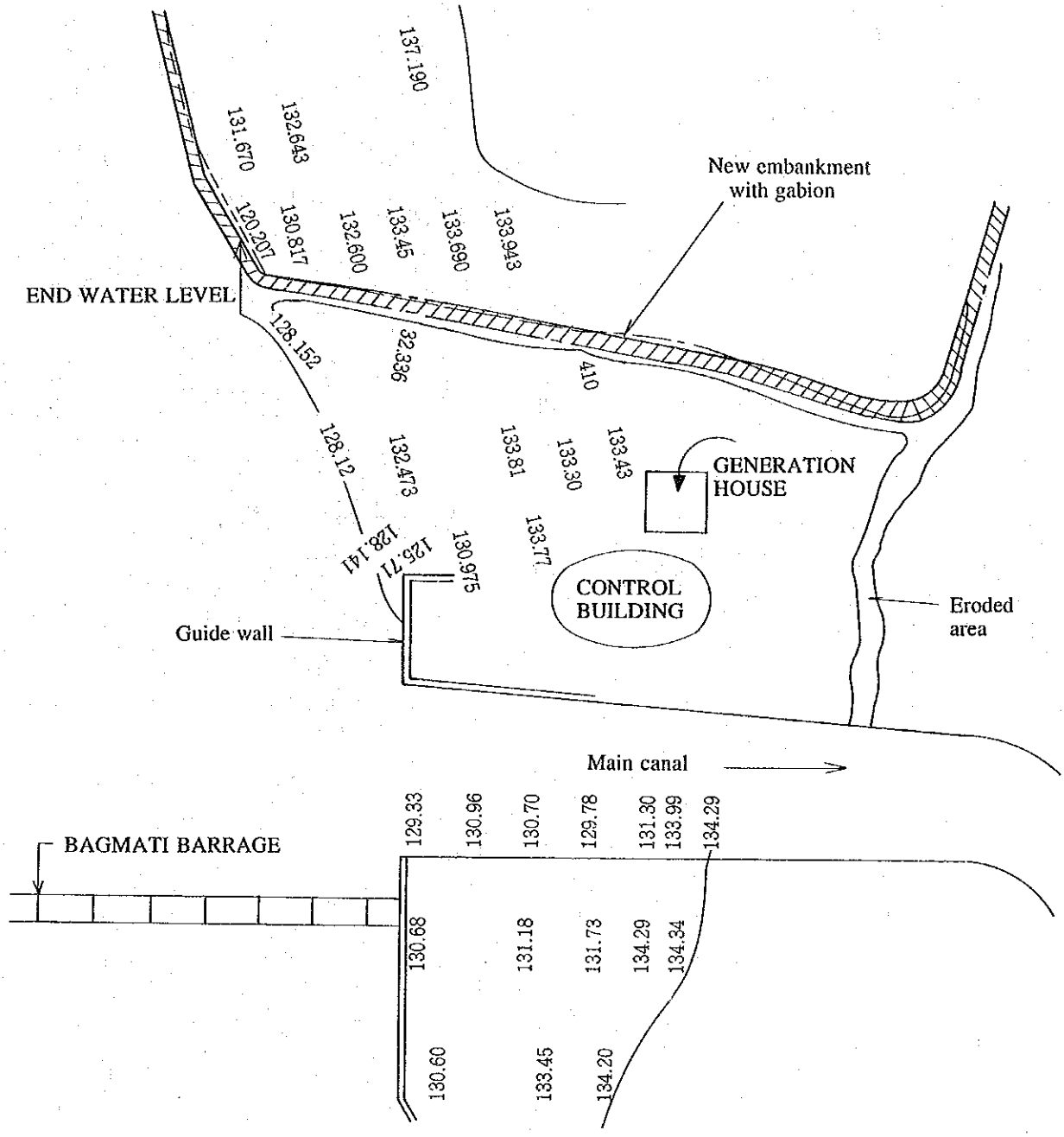


Fig. 5.7 Map of Left Bank of Bagmati Barrage

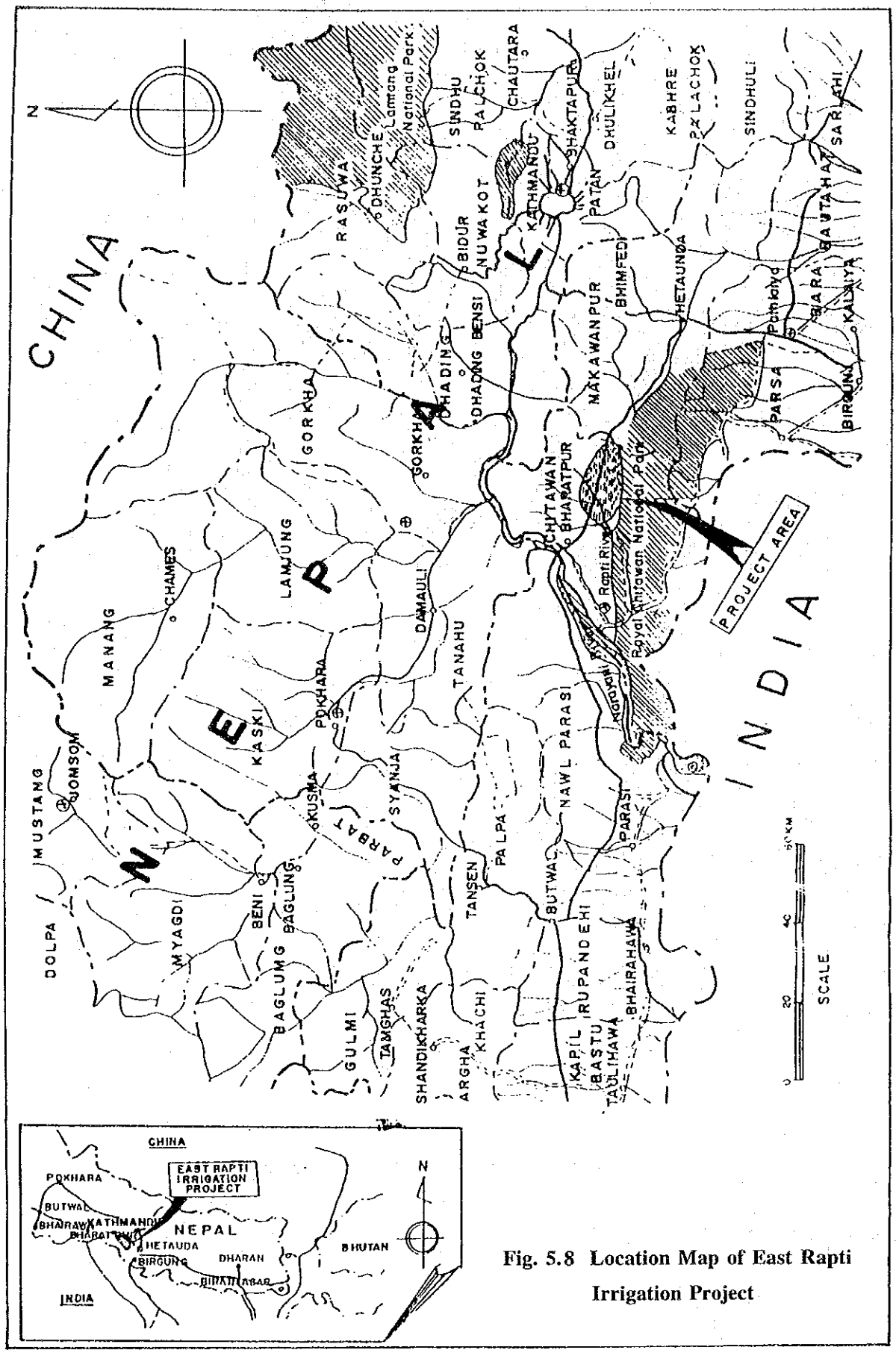
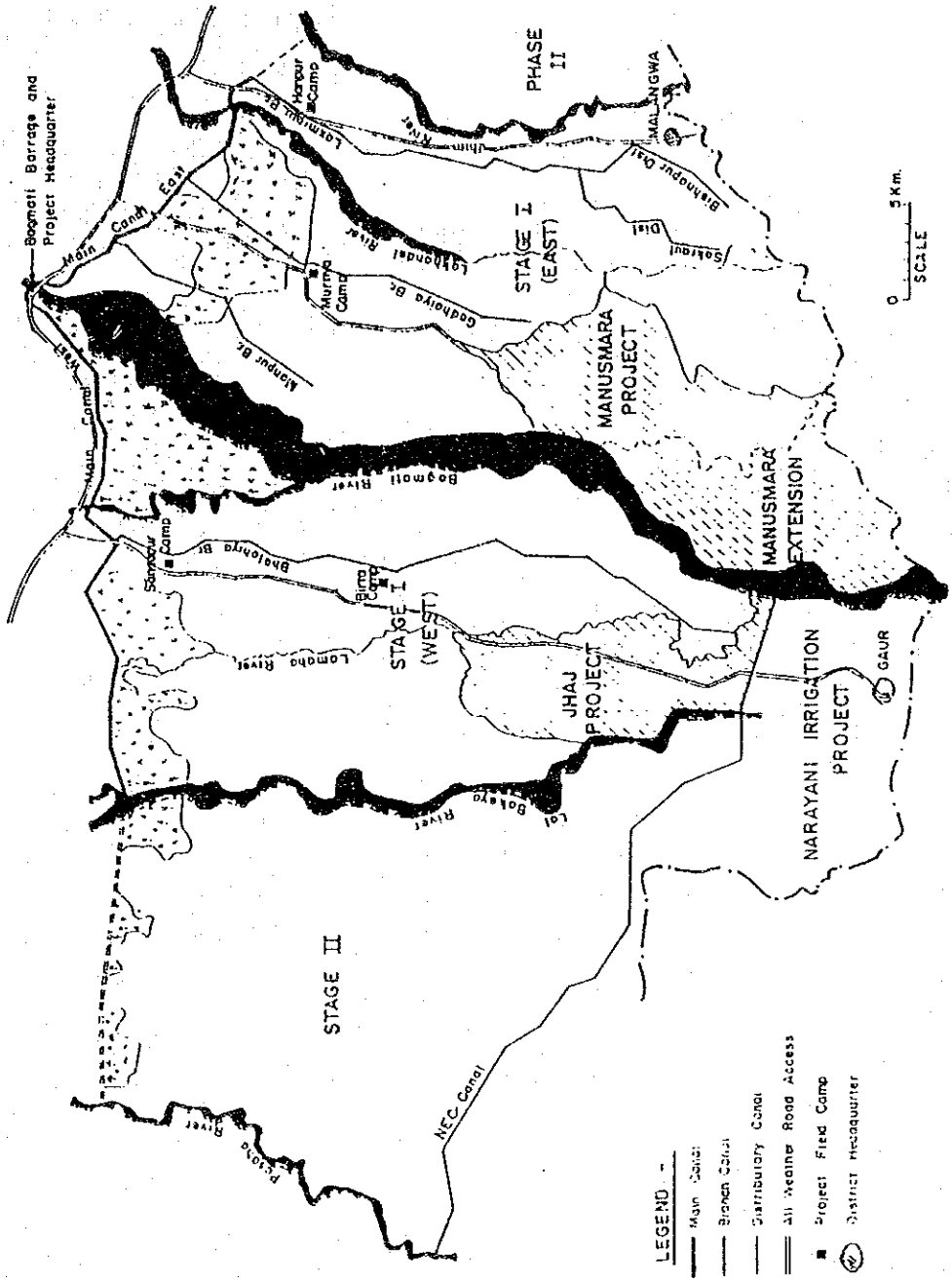


Fig. 5.8 Location Map of East Rapti Irrigation Project



Bagmati Irrigation Project
Present Status

HIS MAJESTY'S GOVERNMENT OF NEPAL
FEASIBILITY STUDY BAGMATI COMMAND AREA DEVELOPMENT PROJECT
ASIAN DEVELOPMENT BANK

Tab. 1. Salient Feature of East Rapti Irrigation Project

	Features	Branch canal	Branch canal No. 1	Branch canal No. 2
I.	NET IRRIGABLE AREA (ha)	9536	22280	1822
		(5434)		
II.	CANAL LENGTH (km)	21.0	6.9	1.7
III.	MAXIMUM DESIGN DISCHARGE (m^3/s)	14.30	3.42	2.73
IV.	TYPE OF CANAL	Generally un-lined trapezodal earth canal		
	HYDRAULIC GRADIENT	1/8500	1/5000	1/3500
		1/5000	1/3000	1/3400
VI.	MAXIMUM SIZE OF CANAL			
	– Canal height (m)	3.12	1.84	1.75
	– Bottom width (m)	6.00	3.00	2.50
	– Top width (t)	15.36	3.52	7.75
VII.	NOS. OP SECONDARY CANALS TO DE DIVERTED	43	16	9
VIII.	NOS. OF RELATED STRUCTURES			
	– Division structures	21	6	5
	– Turnout	6	2	2
	– Check	13	0	0
	– Check drop	0	4	4
	– Culvert	11	5	4
	– Drop	0	10	6
	– Syphon	15	0	1
	– Chute	0	0	1
	– Spillway	5	0	0
	– Spillway cut wasteway	2	1	1
	– Superpassage	1	0	0
	– Terminal structures	1	1	1
	– Measuring device	1	0	0
	– Footpath bridge	17	0	0
	– Cross drain	26	1	4

* This figure shows the net irrigable area directly commanded by MC.

6. Findings and Recommendations of Debris flows and landslide Expert Team

Many landslides, slope failures, collapses and debris flows caused by the 19-21 July 1993 heavy concentrated rainfall occurred on the Midland mountain area in Nepal. Landslides phenomena are varied by the slope situation and geological structure condition. In this chapter, landslides which strongly affected socially and economically important infrastructures are dealt with in the view point of construction and planning of stabilization measures.

6.1 General background of geology and geomorphorogy in the investigation area

<Geomorphorogy>

From the view point of topography, Nepal is divided into 5 topographic zones; Great Himalayas, Lesser Himalayas, Midland, Siwalik zone and Terai plain. The landslide investigation areas are belonging to Midland region. The surveyed area elevation extends from 600 m to 2,500 m, and steep slopes are developed on mountain side produced by river erosion. Local topographic development process of this region is controlled by geological structure and river erosion. Typical cuestas topographies resulting in geological structure and river scouring usually develop on mountain slope.

<Geology>

Geological structure of the investigated area is controlled by large syncline and major thrust. The syncline is named as Mahabharat syncline. The syncline axis extends E-W direction through the central part of Kathmandu basin. Distinct thrust distributes between Precambrian Bhimphedi group and Paleozoic upper Nawakot group. A river channel course of upper part of the Trisuli river is controlled by this thrust structure. Most sedimentary rocks in this region consist of steep dipping bedding plane. Joint system has strongly developed in the target region.

Geology of the research area mainly consists of granite, crystalline schist, meta sediment, limestone and gneiss (Fig. 6.1.1). The geologic formation ages of this region are from Precambrian to Paleozoic era. Two large intrusive granitic masses distribute on the research area. The Daman granite mass covers from upper stream of right side of Rapti river to Daman area. Narayan Than granitic masses extends to E-W direction on upper left stream of the Trisuli river. Because that mass intrudes along the fault zone, which tends to E-W direction. Crystalline schist and meta sediment rocks predominantly distribute on Rapti river region. Lower Paleozoic formations of meta sediment rocks distribute along the Trisuli river.

6.2 Countermeasures against Debris Flows

6.2.1 Introduction

This chapter deals with countermeasures against debris flows to be incorporated into the rehabilitation programme for the disaster caused by the heavy rainfall in July 1993.

Debris flows occurred at so many places in mountain areas of the Central Region. However, due to time constraints and difficult accessibility as well, only several places in Makawanpur District, the hardest hit by the July disaster, were selected for field inspections and were referred to in this chapter.