JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF IRRIGATION
MINISTRY OF WATER RESOURCES
THE KINGDOM OF NEPAL

THE STUDY
ON
FLOOD MITIGATION PLAN
FOR
SELECTED RIVERS IN THE TERAI PLAIN
IN
THE KINGDOM OF NEPAL

FINAL REPORT

VOLUME II

MAIN REPORT

MAY 1999

NIKKEN Consultants, Inc.
NIPPON KOEI CO., LTD.

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VOLUME I : EXECUTIVE SUMMARY

VOLUME II : MAIN REPORT

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- A2: FLOOD MITIGATION PLAN/LOHANDRA RIVER
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US$ 1.00=NRs.67.93

¥ 1.00 =NRs.0.59

PREFACE

In response to a request from His Majesty's Government of Nepal, the Government of Japan decided to conduct the Study on Flood Mitigation Plan for Selected Rivers in the Terai Plain in the Kingdom of Nepal and entrusted the study to the Japan International Cooperation Agency (JICA).

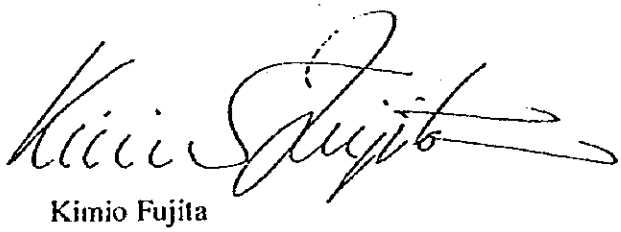
JICA selected and dispatched the study team headed by Mr. Noboru Jitsuhiro of NIKKEN Consultants, Inc. and composed of NIPPON KOEI Co., Ltd. to Nepal, three (3) times between December 1997 and May 1999. In addition, JICA set up an advisory committee headed by Mr. Hidetomi Oi, Development Specialist of JICA, between December 1997 and May 1999, which examined the study from specialist and technical points of view.

The Team held discussions with the officials concerned of His Majesty's Government of Nepal and conducted field surveys at the study area. Upon returning to Japan, the Team conducted further studies and prepared this final report.

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

Finally, I wish to express my sincere appreciation to the officials concerned of His Majesty's Government of Nepal for their close cooperation extended to the Study.

May, 1999



Kimio Fujita
President
Japan International Cooperation Agency

May 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita

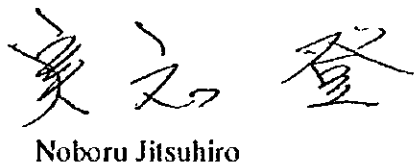
Letter of Transmittal

We are pleased to submit to you the Final Report on "the Study on Flood Mitigation Plan for Selected Rivers in the Terai Plain in the Kingdom of Nepal". We carried out the Study for a period of 18 months from December 1997 to May 1999.

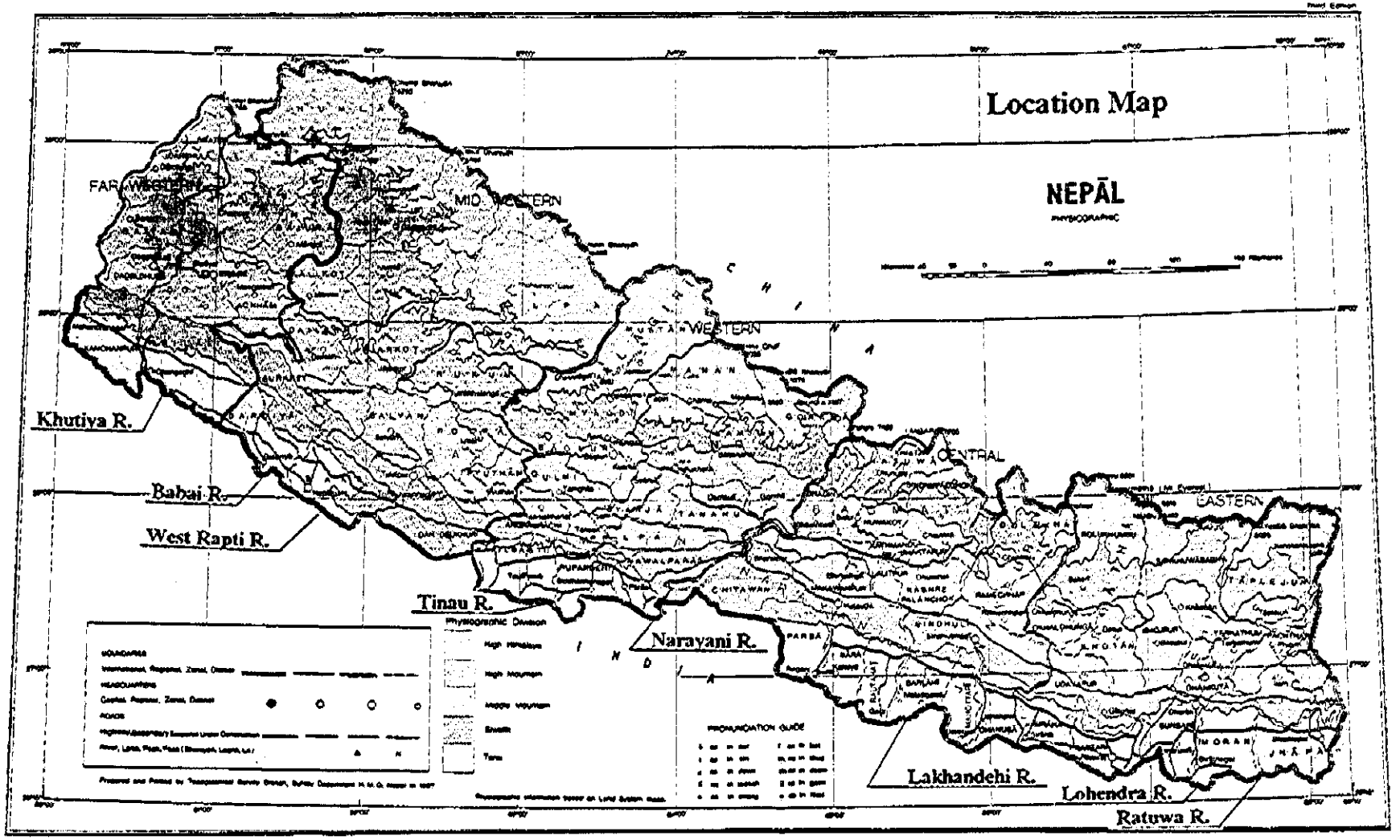
The Final Report presents a flood mitigation master plan for eight (8) river basins and a result of feasibility study for the priority projects (the Lakhandei and Babai river basins). The Final Report proposes a series of low-cost and sustainable flood mitigation activities consisting of watershed management, river control and community development components. The priority projects are proved technically viable, economically feasible, and socially and environmentally acceptable, and are recommended for immediate implementation as pilot project for flood mitigation in the Terai plain.

We wish to take this opportunity to express our sincere gratitude to your Agency and the Advisory Committee for the Study. We also wish to express our deep gratitude to His Majesty's Government of Nepal, the Embassy of Japan in Nepal, the JICA Nepal Office and JICA experts for close cooperation and assistance extended to us during our investigation and study.

Very truly yours,



Noboru Jitsuhiro
Team Leader,
The Study on Flood Mitigation Plan
For Selected Rivers in the Terai Plain
In the Kingdom of Nepal



His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

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JAPAN INTERNATIONAL COOPERATION AGENCY

MAIN REPORT

MAIN REPORT

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LIST OF ABBREVIATIONS AND ACRONYMS.

APP	Agricultural Perspective Plan
CIDA	Canadian International Development Agency
CDRC	Central Disaster Relief Committee
CO	Community Organization
DDC	District Development Committee
DDRC	District Disaster Relief Committee
DHM	Department of Hydrology and Meteorology
DOA	Department of Agriculture
DOE	Department of Environment in MOPE
DOF	Department of Forest
DOI	Department of Irrigation in MOWR
DONP	Department of National Park
DOR	Department of Roads
DOSC, DOSCWM	Department of Soil Conservation and Watershed Management in MOFSC
DPNET	Disaster Preparedness Network
DPTC	Water-induced Disaster Prevention Technical Center
DSCO	District Soil Conservation Office
EAS	Environmental Assessment Study
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment
ENTMP	Eastern Nepal Topographic Mapping Project
EPA	Environmental Protection Act
ES	Environmental Study
ET	Environmental Test
FAO	Food and Agricultural Organization of the UN
FEMD	Flood Control, Environmental & Mechanical Division
FS	Forest Survey
GAD	Gender and Development
GDP	Gross Domestic Product
GNP	Gross National Product
GTZ	German Aid Agency
HMG/N	His Majesty's Government of Nepal
IBRD	International Bank for Reconstruction and Development (WB)
ICIMOD	International Center for Integrated Mountain Development
IDNDR	International Decade for Natural Disaster Reduction
IUCN	International Union for the Conservation of Nature
JICA	Japan International Cooperation Agency
LGI	Local Governing Institutions

LRMP	Land Resource Mapping Project
LWS	Lutheran World Services
LZMP	Lumbini Zone Mapping Project
MC	Municipal Council
MLD	Ministry of Local Development
MOFSC	Ministry of Forest and Soil Conservation
MOH	Ministry of Home
MOPE	Ministry of Population and Environment
MOWR	Ministry of Water Resources
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organization
NP	National Park
NPC	National Planning Commission
NRCS	Nepal Red Cross Society
RCIW	Rural Community Infrastructure Works Program
RIO	Regional Irrigation Offices in DOI
SCWM	Soil Conservation and Watershed Management
SOW	Scope of Work
SP	Sub-Project
UN-DMS	UN Disaster Management Secretariat
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
VDC	Village Development Committee
WB	The World Bank
WECS	Water and Energy Commission Secretariat
WFP	World Food Program
WMP	Watershed Management Plan
WNTMP	Western Nepal Topographic Mapping Project
WR	Wildlife Reserve.
WRES	Water Resources and Energy sector of the ECR

ha	hectare, (10,000 square meters)
km	kilometer (1000 meters)
Ma	Mega d'annees (million years)
NRs, Rs	Nepali Rupee
s, sec	second
t, ton	Metric ton
US$	US dollar
¥	Japanese yen
%	percent

CHAPTER 1 INTRODUCTION

1.1 Background of Study

The Terai Plain, which occupies the southern part of the territory of the Kingdom of Nepal, has about 14 % of land area and about 50 % of population of the country. The plain is the prominent granary area, and recently the population in the plain has increased rapidly. The East-West highway, which is the only trunk road crossing the country, takes a route approximately on the boundary of the mountainous watershed area and the plain.

The rivers in the plain, suffering from flash flooding and much sedimentation, cause damage every rainy season to infrastructures such as bridges, roads, houses and farm lands and even result in the loss of life. His Majesty's Government of Nepal (hereinafter referred to as "HMG/N") has been taking some flood mitigation measures in these disaster-prone areas. These measures, however, were limited to remedial ones. The implementation of effective measures is difficult due to the lack of an overall flood mitigation plan for the basin.

Disaster prevention is an important task to alleviate poverty in the country as stated in the Ninth Plan. It is required to draw up a master plan for flood mitigation and to implement effectively the measures based on the master plan.

Under these circumstances, HMG/N requested technical cooperation on the flood mitigation from the Japanese Government. In response to this request, the Government of Japan decided to conduct a Study on Flood Mitigation Plan for Selected Rivers in the Terai Plain in the Kingdom of Nepal (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, decided to undertake the Study in close cooperation with the concerned authorities of HMG/N.

1.2 Objective of Study

The Study aims:

1) To formulate a Master Plan for flood mitigation of eight(8) rivers in the Terai plain,
2) To conduct a Feasibility Study for the priority (urgent) project(s) identified in the Master Plan, and
3) To carry out technology transfer to the counterpart personnel of HMG/N in the course of the Study.

1.3 Study Area

The Study Area of the Master Plan shall cover the eight (8) selected rivers in the Terai plain in the Kingdom of Nepal (hereinafter referred to as "Nepal"). The selected rivers are the Ratuwa, Lohandra, Lakhandei, Narayani, Tinau, West Rapti, Babai and Khutiya river basins (Fig. 1.1).

The Feasibility Study shall cover two to three river basins selected for the priority project(s) as a result of the Master Plan study.

1.4 The Study

For the implementation of the Study, JICA organized a Study Team and an Advisory Committee, while HMG/N organized a Steering Committee among the governmental agencies concerned. The Department of Irrigation, Ministry of Water Resources is the leading counterpart agency for the Study. A list of members of the Study Team and Advisory Committee of JICA, and Steering Committee and counterparts of HMG/N is presented in Table 1.1.

The Study is implemented in two phases, i.e., Phase-I for the formulation of the Master Plan and the selection of priority projects, and Phase-II for the Feasibility Study. Each phase comprises work in Nepal and work in Japan. A flow chart of the Study is shown in Fig.1.2.

Phase-I Study: The Phase-I study started in early December 1997 and the Study Team was present in Nepal from December 7, 1997 to March 25, 1998. During its stay in Nepal the Study Team, in collaboration with counterpart agency of HMG/N for the Study, conducted data collection, field investigations and a preliminary study for the

flood mitigation plan.

At the end of the first work in Nepal, the concept of a flood mitigation Master Plan was discussed with the HMG/N and two river basins for the priority projects, the Lakhandei and Babai river basins, were selected and agreed to.

Following the work in Nepal, the study was continued in Japan to formulate a flood mitigation Master Plan for the eight rivers. All the study results on the flood mitigation Master Plan and selection of rivers for the priority project were compiled in the Interim Report.

Phase-II Study: River surveying and topographic mapping for the Phase-II study started in May 1998 and the full-scale Study Team was present in Nepal again from July 2 to November 26, 1998. In early July of 1998, the Interim Report was submitted and explained to the HMG/N. During the second work in Nepal, a Feasibility Study for the priority project was conducted in collaboration with counterpart agency of HMG/N for the Study. In succession, the Feasibility Study was continued in Japan and all the study results were compiled in the Draft Final Report.

In the beginning of February 1999, the Study Team visited Nepal to present and discuss the Draft Final Report and to hold the Technical Transfer Seminar. After receiving comments from HMG/N on the Draft Final Report, the Final Report for the Study was prepared.

Technology Transfer: In addition to the on-the-job training through collaborative work with the counterpart personnel of HMG/N, the following undertakings were made through Phase-I and II work period:

1) Regular and occasional meetings to discuss on the technical topics.
2) Technical training program in Japan, one DOI official each for Phase-I and Phase II.
3) Technical transfer seminar for two days in mid-February 1999.

Table 1.1

LIST OF MEMBERS

JICA

1. JICA Study Team Members

Noboru Jitsuhiro	Team Leader/Flood Mitigation
Takuro Terashima	Co-Leader/River
Eiichi Hayakawa	Sabo
Hideki Araki	Hydrology and Hydraulics
Kunihiko Okada	Facility Design
Tatsumi Tanabe	Flood Damage Survey
Takashi Yokokawa	Survey
Katsuhiko Masaki	Socio-economic Study
Keith Openshaw	Environment
Makoto Kodama	Coordinator

2. Members of JICA Advisory Committee

Hidetomi Oi	Chairman
Takeshi Wakai	Member

3. JICA Officers in Charge

Dai Masuda	Task Manager
Yoshio Fukuda	Task Manager
Koji Yamada	Assistant Resident Representative, Nepal Office
Hiroyasu Tonokawa	Assistant Resident Representative, Nepal Office

HMG/N

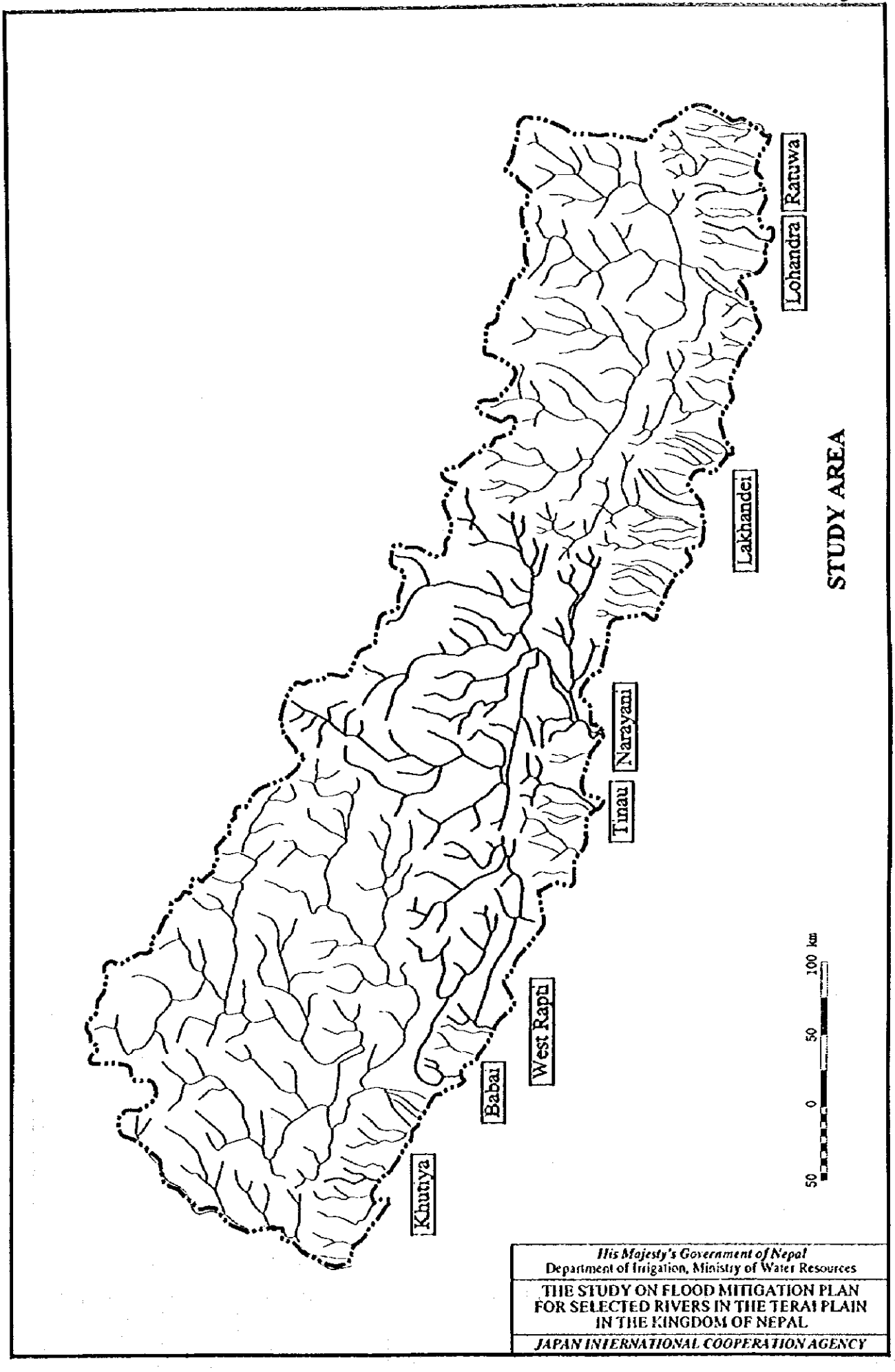
1. HMG/N Steering Committee Members

M.N. Aryal	Chairman/Director General, DOI
S.P. Sharma	Member/Deputy Director General, DOI
M.R. Sharma	Member/Under Secretary, MLD
P. Kunwar	Member/Under Secretary, MPE
M.S. Poudel	Member/Project Manager, DPTC
K.P. Rijal	Member/Project Manager, DPTC
N.P. Bhattarai	Member/Senior Divisional Engineer, MOWR
G.B. Katuwal	Member/Senior Divisional Engineer, MOWR
B.D. Shrestha	Member/Senior Divisional Geologist, DSC
B.K. Rimal	Member/Under Secretary, DSCWM
A.N. Mishra	Member Secretary/Deputy Director General, River Training Environment and Mech. Division,

2. HMG/N Counterparts

M.N. Manandhar	Project Manager, DOI
R.R. Shrestha	Engineer, DOI
R. Kunwar	Engineer, DOI
H.K. Jha	Assistant Soil Conservation Officer, DOI
P. Poudyal	Chief, DOI Jhapa
N. Lama	Chief, DOI Morang
U.K. Jha	Chief, DOI Sarlahi
S. Sijapati	Chief, DOI Sarlahi
B.K. Pradhan	Chief, DOI Chitwan
S.C.Verma	Chief, DOI Chitwan
D.N. Mishra	Chief, DOI Rupandehi
M.L.K. Shrestha	Chief, DOI Banke
G.S. Singh	Chief, DOI Kailali

Fig. 1.1


Lohandra
Ranuwa
Lakhandei
STUDY AREA
Narayani
Tinau
West Rapti
Babai
Khutiya
50
0
50
100 km
His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN
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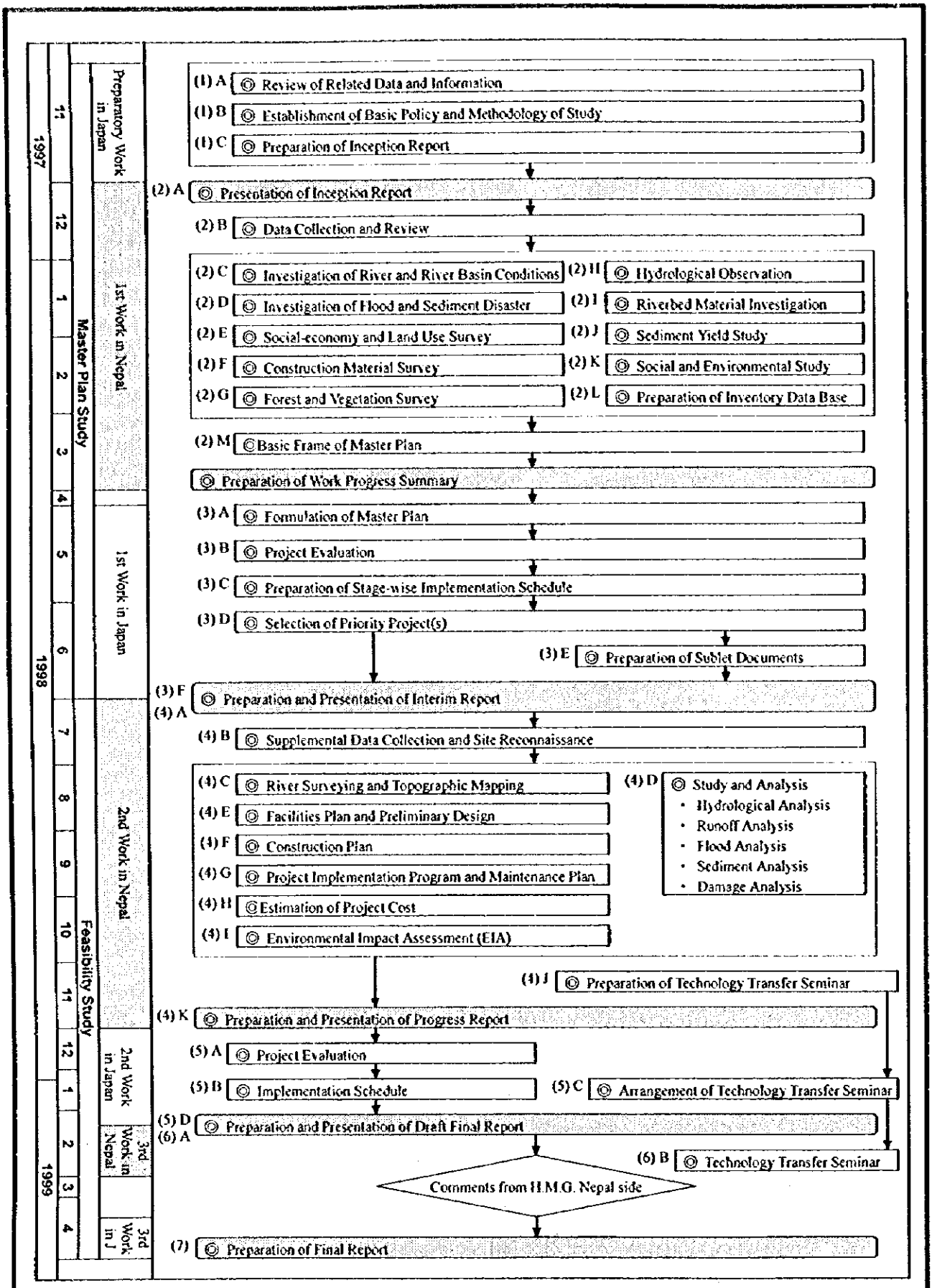
IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 1.2



FLOW CHART OF THE STUDY

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

PART-I: MASTER PLAN STUDY FOR EIGHT RIVER BASINS

CHAPTER 2 EXISTING CONDITIONS

2.1 Topography and Geology

2.1.1 Geo-history and Geomorphology

The Himalayas, the most magnificent natural feature on the surface of the earth, are believed to have originated in a broad sea basin bordering a landmass. This sea lies between Gondowana land in the south and the Eurasian plate in the north.

In the Eocene (65 million years ago), the Indian sub-continental plate divided from Gondowana land and abutted against the Eurasian plate. The meeting zone of the two plates is called as Indus-Tsangpo suture zone. Geological records show that the Himalayas were formed from the Tethys sea, and this sea was nearly filled up with sediment during the Cretaceous period. The clashes of plates lift the seabed to shape the Himalayan mountains. Antecedent rivers such as the Kosi, Gandaki, Karnali, and Mahakali started eroding the mountains, draining southwards.

In subsequent times after the rise of the Himalayas, the Mahabharat ranges were formed and the rivers that flowed south were blocked. The interrupted rivers started flow parallel to the Mahabharat ranges in search of some weak points, such as faults, folds, or low elevations, to exit from the mountains. This led to the formation of longitudinal valleys.

More recently, the Siwalik (Churia) hills and the Indo-Gangetic basin were formed. The Indo-Gangetic basin, consisting of alluvium nearly 1,600 meters deep, was filled with clastic rocks derived from the Himalayas over a period of 1 to 10 million years. Finally, all these natural forces create the present topographical and geological formations.

Figure 2.1 shows the general geomorphologic view in the Nepal Himalayas and its neighborhood. General features of topography and geology of Nepal are shown in Figs. 2.2 and 2.3.

2.1.2 Topographical and Geological Zones

The topography and geology of the Nepal can be divided into several zones; Inner Himalayan valleys, Higher Himalayan zone, Lesser Himalayan zone, Siwalik (Churia)

hills, Dun valleys, and Terai plain as shown in Fig. 2.4.

Inner Himalayan Valleys: In the north of the Higher Himalayan zone and south of Tibetan plateau, situated are the inner Himalayan valleys. In these valleys the annual rainfall is small below 250 mm. Major rivers of Nepal such as the Kosi, Gandaki, Karnali and Mahakali originate in this zone and are snow-fed.

Higher Himalayan Zone: Snow-covered peaks and deep "U"-shaped glacial hanging valleys are the main topographic features in the higher Himalayan zone. The mountains above 3,800 m above mean sea level (m,MSL) are mostly barren of vegetation and above 4,800 m,MSL snow covered. The majority of higher peaks are located in this zone. On mountain slopes, glacial moraines are found. Sometimes the moraines form glacial lakes.

Lesser Himalayan Zone: This zone occupies the central part of the Himalayan mountains. It consists of a series of mountain ranges rising above its low rolling hills. Generally, the Lesser Himalayan zone is divided into two sub-ranges, namely, the Midland and Mahabharat ranges from north.

1) **Midland Ranges:** The Midland ranges consist of low-lying hills, river and tectonic valleys. The Midland ranges are composed of soft rocks (phyllite, slate and dolomite) and thick soil covers this area, hence it is heavily populated. Because soft rocks weather easily, the Midland ranges show low and mild slope hills. Nearly all the hill slopes are formed from the talus of landslide and rock fall.

2) **Mahabharat Ranges:** The Mahabharat ranges consist of harder rock than the midland ranges. The topography is steeper on the southern side slope comparing to the northern one. Landslides are common on the northern slope and rock falls on the southern slope. The steep topography is attributed to the main boundary fault (MBF) which lies mostly at the southern foot of the ranges.

Siwalik (Churia) Hills: The Siwalik (Churia) hills are the low-lying hill range bordering the Indo-Gangetic plain in the south and Himalayan mountains. Mostly it consists of rocks of alternating beds of clay, sandstone, sand and pebble. The rocks generally dip northwards. Alternating loose and hard rock beds have produced the

escarpment feature. In many places, rugged land with numerous gullies and mound of talus are found.

Dun Valleys: The Siwalik hills make separate hill ranges to the east-west direction except in some places where it merges with the Mahabharat ranges. The separate ranges form Dun Valleys as seen in Trijunga, East Rapti-Nawalpur, Deokhuri (West Rapti), Dang Valley, Surkhet Valley, etc. The Dun Valleys are fertile and are similar to the Terai plain in nature.

Terai Plain: The plain is the continuation of Indo-Gangetic plain having an elevation from 50 to 300 m,MSL. The Terai slopes toward south with steeper slope at the foothill region and nearly flat at the southern end. The Terai plain is generally divided into three zones, i.e., Bhabhar zone (foot of the hills), marshy area (spring line), and southern Terai (Indian border).

1) **Bhabhar Zone:** The Bhabhar zone lies at the foot of the Siwalik hills. It is composed of boulders, pebbles, cobbles and sand transported by rivers from the Siwalik hills or the Mahabharat ranges. In most cases, the rocks are sandstone, quartz or dolomite. The foot of hills is covered with evergreen forests.
2) **Marshy Area:** The marshy area is found in the south of Bhabhar zone where two lithological units having different porosity and permeability meet or inter finger along with the change of elevation, mainly resulting in spring lines, ponds, lakes, etc.
3) **Southern Terai:** This nearly flat and not well-drained areas is found between marshy area and the India-Nepal border. The area is composed of sand, clay and silt with less pebble.

2.2 Meteorology and Hydrology

2.2.1 Meteo-hydrological Features of Nepal

Nepal is located at the latitude from 26°30'N to 30°30'N and the longitude from 80°00'E to 88°30'E. Variation of altitude is large ranging from about 50 to 8,848 m,MSL, which causes variety of climatic conditions in Nepal from Tropical to Tundra . In addition to the big difference in altitude, dry and rainy seasons due to the monsoons bring about extreme climatic contrasts.

Air Temperature: Altitude has a direct effect on temperature. The higher the altitude the cooler the climate. Below 600 m,MSL the climate is tropical with a hot and moist atmosphere. Lowlands like the Terai, the Inner Terai and the Midland are warmer. In contrast the hilly and the Himalayan regions are cooler. The coldest month is January and the hottest period falls between June and July. The temperature rises from March to June, while it decreases from October to January. In general, the monthly temperature varies from the eastern Terai to the western Terai.

Rainfall: Nepal is influenced by the southeast monsoons from June to September. The monsoon air-stream is forced to rise as it meets the Himalayas, and heavy rainfall takes place on the south-facing slopes. Heavy rainfall is recorded along the Siwalik/Mahabarat hills and on the southern margin of the mountain zone. In the lee of these zones, the rainfall is reduced. Therefore, the heavy rainfall zones tend to run in parallel with the mountain ranges. The monsoons have little effects in the areas above 3,000 m,MSL. Figure 2.5 shows the isohyetal maps of average annual rainfall (1971-85) and that during monsoon periods (1961-85).

Hydrology: In the mountain and midland zones the geology tends to promote rapid run-off with dense network of small steep streams draining into the major rivers. In contrast, the Siwalik hills located on the Terai margins and the inner Terai, the geology promotes groundwater storage.

Run-off is concentrated in the monsoon season. Melted snow contributes to the run-off mainly from March to July and increases the flow of the major rivers before the monsoon rains. In the catchment areas which lies below 3,000 m,MSL, there is insignificant contribution from snow. Stream records in these catchment areas show no significant rise in flow before the first monsoon rains. Figure 2.6 shows the monthly flow at specific points for the major rivers.

2.2.2 Meteo-Hydrological Conditions in Study Area

The meteorological observation records in the Study Area and other related areas were studied based on the monthly data of air temperature, relative humidity, and rainfall. Data used for the study are those of 10-year period from 1985 to 1994 at 29 stations in Nepal. Table 2.1 and Fig. 2.7 show the summary of the result.

2.3 Environment

2.3.1 Environmental Overview

The elevation of the Terai plain is between 50 m and 300 m above mean sea level (m,MSL). About 60 main rivers, including three major river systems, bisect the plain from north to south. The natural climatic climax vegetation is sal forests (*Shorea robusta*), but there is a profusion of plants and animals, many of which are protected to varying degrees in national parks, buffer zones and state forests.

The 1998 population of the Terai is about 11.0 million, (9.7 million in rural area and 1.3 million in urban area) out of a country total of 22.2 million. Because of migration into the area, the population of the Terai is anticipated to double in 20 years time, whereas that of Nepal will double in about 35 years time: thus by 2020, the Terai may contain 67 % of Nepal's population.

Apart from being the habitat of many wild plants and animals, some of which are rare and/or endangered species, the Terai is the main grain producing area in the country. In order to meet the growing demand for food, while at the same time protecting the indigenous flora and fauna, agricultural productivity has to increase. This should be done by increasing unit production, extending double and triple cropping through irrigation, and reclaiming some of the sterile land, rather than converting more forest land to agriculture, as has been done previously and to a small extent is occurring today.

Hence, it is important to preserve the existing agricultural land from erosion and degradation; this latter occurs when sand and gravel are deposited on the alluvial soils. This is why it is necessary to develop a practical and viable plan to reduce the detrimental effects of the annual monsoons, while at the same time ensuring that the habitat of indigenous flora and fauna is not only maintained, but also enhanced.

During the monsoons, rivers change course frequently, leading to bank erosion and flooding of nearby farmland.

(1) National Park and Wildlife Reserve

The national park in Chitwan and the wildlife reserve in Bardiya are fully protected from encroachment. There are also buffer zones round each of these parks, with restrictions on the use of forestland and riverbanks. Sometimes, park animals such as

the rhinoceros invade farmers' fields and graze the crops. In rare instances, farmers have abandoned the land to pasture. Crocodile also take the occasional small domestic or farm animal while it is drinking at the river.

The total area of Chitwan national park is 93,200 ha, 80 % being forest and the remaining 20 % grasslands. The Narayani river runs along the park's western border. The East Rapti river joins the Narayani river forming the park's northern border. Much of the park is elevated. Thus, during the monsoons, river water tends to flow on farm and forestlands opposite the park. Some dikes and gabions have been constructed, but these protections are incomplete.

Bardiya wildlife reserve has an area of 96,800 ha, about 85 % being forest and 15 % grassland. The Babai river runs through this park. Only when it emerges from the park at its southern end, flood mitigation measures are contemplated. From here, the distance to the border is some 45 km. Thus flood mitigation interventions on the Narayani, East Rapti and Babai rivers will have little effect, if any, on these two national parks.

(2) Wetlands

Of far more importance, are the potential effects of flood mitigation measures on the listed wetland. Table 2.2 gives the listed wetlands on six of the eight-river floodplains in the flood mitigation program.

There are three large and three small wetlands. Two of the large ones are associated with the Chitwan national park and Bardiya wildlife reserve on the Narayani and Babai rivers. These floodplains start in the national park/wildlife reserve and continue through the buffer zones. Some flood mitigation interventions may affect these floodplains, but 25 % of the Narayani and 10 % of the Babai floodplains are already farmed and have settlements on them. However, bearing in mind the needs of the human and domestic animal populations, the wetlands will be given high priority if measures are suggested in their vicinity, and environmental impact assessments (EIA) will be undertaken.

(3) Impact of Flood Mitigation Interventions

It is unlikely that these national park and wildlife reserve will be affected by proposed flood mitigation interventions. What is more likely to affect the environment of the

buffer zones, wetland areas, forests and even the parks is the anticipated doubling of the population in the Terai by 2020. Unless existing agricultural land can be protected from erosion and degradation and unless agricultural productivity increases at the same pace as population increase, more forests and wetlands will be converted to arable agriculture.

The main purpose of the flood mitigation study is to propose interventions to reduce the disrupting effects of the monsoon flooding. Such measures should minimize erosion and land degradation in the Terai. Indeed, the measures may enable some of the existing degraded land to be reclaimed and brought back into productive use. Therefore, flood mitigation measures are important interventions for environmental, economic and social protection.

2.3.2 Environmental Organizations and Institutions

There are many organizations and institutions concerned with environmental conservation in Nepal, but only the relevant ones dealing with environmental conservation in the Terai will be dealt with here.

The Environmental Division of the Ministry of Population and Environment has overall responsibility for environmental matters in Nepal. In June of 1997, Environmental Conservation Rules were issued under section 24 of the 1997 Environmental Conservation Act. These rules lay down procedure to be followed when new projects are proposed or existing projects extended. Central to approval of any projects is the consent (and inputs) from affected villages, municipalities and districts, through their representative Village Development Committee (VDC), Municipal Council (MC) and District Development Committee (DDC).

There is an environmental advisory body called the Environmental Protection Council. It is made up of representatives from government and non-government bodies. This council provides policy guidance and suggestions to the government regarding environmental protection matters. It also facilitates co-ordination for different government and non-government agencies.

2.3.3 Environmental Conservation Rules

The Environmental Conservation Rules (ECR) for Nepal govern all new project proposals and extensions to existing projects. All projects have to undergo an Initial

Environmental Examination (IEE) or an Environmental Impact Assessment (IEA). Such environmental studies require detailed investigations and are time consuming. At present, there is no screening mechanism to separate out projects that will be benign or beneficial to the environment. Also, the rules assume that most projects will be small and cover a discrete time period.

However, the flood mitigation plan for the eight rivers in the Terai, consisting of structural and non-structural interventions, should have a beneficial impact on the environment. The plan endeavors to protect existing wetlands, control floodwater during the monsoons, prevent excessive damage to farmer's fields, control erosion and reduce damage to property. The average length of the rivers in the plain is about 50 km and the flood mitigation plan to be successful will be an on-going initiative.

Nevertheless, as the rules are written today, either an IEE or an EIA must be undertaken along the whole length of each river, because some intervention is proposed for every sector of each river. Table 2.3 is a summary of the procedure for undertaking an evaluation of the environmental impact of a project proposal.

2.3.4 Proposed Changes to the Environmental Conservation Rules (ECR)

All Water Bodies: The ECR states in its section K (8) that an EIA has to be carried out in "Areas containing water (still or flowing)." This directive covers all water bodies without exception. However, the directive appears to cover only wetlands, not all water bodies.

Notification and Comments: It is also suggested that the time period for notification and comments concerning the scope of work and the results of an IEE or an EIA be reduced from 30 days to 14 days. Also, the method of notification should be by publication in the press and/or by broadcast in the media, rather than by mail and/or hand delivery.

Environmental Screening: It is recommended that the initial environmental screening should be undertaken for all the proposed interventions, and rigorous environmental examinations should be implemented only on critical interventions and/or parts of the system which may adversely affect the environment.

Present Environmental Study: Initially for the Master Plan, only an Environmental

Study (ES) will be undertaken for the eight rivers included in the Plan. This ES will consist of an environmental screening, which will highlight those areas requiring further examination. Only two or three of these eight rivers will be subject to a detailed flood mitigation proposal. Here a comprehensive plan will be drawn up specifying the interventions required to prevent flood damage. It is suggested that for these rivers, only those portions of the rivers, highlighted in the initial ES, should be subject to an IEE or an EIA and not the whole length of these river systems in the Terai plain.

2.4 Socio-Economy

2.4.1 Country

Nepal is a landlocked country with a total area of 147,181 km^2. The current estimated population is 21 million (as of 1995), with annual growth of about 2.5 %. Nepal, with a per capita income of around US$ 200 per annum, is classified as one of the least developed countries (LDCs) in the world. The GDP growth rate has been between 4% and 5 % per annum during the past 10 years (Table 2.4).

Like other LDCs, Nepal is a predominantly agrarian economy. Over the last 10 years the share of the agriculture sector in Nepal's GDP has been between 40 and 50 %. In addition, more than 80 % of the labor force is dependent upon agriculture. On the other hand, the industrial sector is comparatively small by international standards, and in recent years, the sector's share in the GDP is approximately 20 % even though industrial worker comprise only 3 % of the total labor force.

2.4.2 Terai

The Terai plain is called the "granary of Nepal", because of the significant contributions the Terai makes to the overall agricultural production. As shown in the table below, almost a half of the country's cultivated land is in the Terai. Moreover, farmers in the Terai produce nearly 60 % of the country's food grain production. The reasons for this high production potential include its sub-tropical climate favorable for farming, higher irrigation potentials, and its fertile land. The marketing potential for the Terai's produce is also greater in comparison to the rest of Nepal, since its terrain is less rugged, and the road network is relatively extensive.

(Terai in the Context of Nepal)

Indicator	Terai	Rest of Nepal
1. Number of Administrative Districts	20	55
2. Population: %	47	53
(Population Density: persons per km^2)	(264)	(91)
(Annual Population Growth Rate, 1971-91: %)	(3.5)	(1.3)
3. Proportion of Nepal's Surface Area: %	23	77
(Cultivated Area: %)	(46)	(54)
(Irrigated Area: %)	(87)	(13)
(Forested Area: %)	(20)	(80)
4. Food Grain Production: %	59	41
(Average Yield of Paddy: t/ha)	(2.54)	(2.07)
(Average Yield of Wheat: t/ha)	(1.6)	(1.4)
(Average Yield of Maize: t/ha)	(1.8)	(1.5)
5. Road Network (km/km^2)	0.129	0.035

Source: 1) Item No. 1, 2 and 5: "Maintaining Granary", Winrock International, 1996
2) Item No. 3 and 4: Statistical Information on Nepal Agriculture, Agriculture Statistical Div., 1996/97

The major pattern of the population flow in Nepal is from the mountain/hill regions to the Terai. As a result, the Terai saw the population growth at nearly three times the rate of the hill and mountain areas. The percentage of the Terai's population increased from 37 % of the whole country in 1971 to 46 % in 1991. The population of the Terai is anticipated to double in 20 years, while that of Nepal is expected to double in about 35 years.

The in-migration to the Terai has been accommodated mostly by new land brought into cultivation. When the southern plains were sparsely inhabited jungles, new migrants were required simply to clear a patch of abundant forests. However, as the "land frontier" was exhausted in more and more places, new migrants are increasingly obliged to settle in flood-prone areas near river banks (or literally even in the river bed).

Much of the cultivated land in the Terai is already double cropped, and also there exist significant amount of triple cropping. Still, as the population movement from the hills and mountains is likely to continue for some time, thus, further efforts to intensify agricultural production are required to slow the process of expansion of settlements and cultivated areas into the flood plains.

2.4.3 Study Areas

(1) Economic Activities

There are 10 districts through which the eight study rivers flow. Agricultural and forest lands make up 92 % of the total plain area (excluding the Siwalik hills and mid-mountain areas) of these 10 districts. More than 70 % of the labor force of the 10 districts works in agriculture.

The 10 district produce a wide range of crops (see Table 2.5), with major crops of paddy, maize, wheat, pulses, and oilseeds. As shown in Fig. 2.8, most of these major crops, but wheat and oilseeds, are grown during monsoon. Although there is also winter paddy and maize, most paddy and maize is grown in summer in the target districts (e.g. in Morang district, the production of winter paddy is about 10 % of that of summer paddy, and maize only 1 %).

(2) Land Ownership

In most of the 10 target districts, the average land holding size has been gradual declining in recent years (Table 2.6). The average size is far below the 16.4-ha ceiling imposed by the 1964 Lands Act. In addition, more than 90 % of the agricultural land is under owner-cultivation in the target 10 districts, although the proportion has been decreasing. Of the approximate 10 % of agricultural land under "formal" tenancy, the most dominant form of agreement is sharecropping.

It should be noted, however, that due to growing land scarcity, as well as increasing demand for land, many landowners are said to enter into informal tenancy agreements with farmers desperately seeking land for cultivation. Since such informal arrangements are not recorded in the official census, the above figure on owner-cultivation should be treated with caution.

Underlying the sharecropping category is a commonly known phenomenon of "dual ownership". The "dual ownership" originated in the land reform scheme in which the Government did not completely transfer land ownership, due to its limited implementation capacity. Given the legal provisions which favor tenants, the dual ownership provides little incentive for landowners to improve the productivity of their land.

In formulating plans for flood mitigation, these complexities nature of the country's land holding should be taken into consideration. To undertake flood mitigation works for land under "dual ownership", it will be imperative to involve both the land owner and the tenant for both of whom are entitled to a certain share of the crop. As informal tenancy agreement discourages landowner to take on responsibilities for land protection, special efforts should be made to motivate them to participate in land protection.

(3) East-West Patterns

Looking at the 10 target districts which scatter across the Terai from the far west to the east, the following major patterns can be observed.

1) Population density declines moving from east (Morang) to west (Kailali), while population growth occurs more rapidly (Table 2.7).
2) Similarly, the percentage of land under cultivation falls moving toward the west, while percentage of area under forest increases.

These patterns are due to the fact that, in general, the history of settlements is longer towards the east. As a result, in-migration in the east is falling to zero, as new lands for cultivation are unavailable. This is reflected in the three districts (i.e., Jhapa, Morang, and Sarlahi) where the recent population growth rates are equal to, or smaller than the national average (Table 2.7). On the other hand, the western districts (especially Kailali and Bardiya) continue to exhibit high population growth, since the land frontiers are relatively open.

In terms of the human development index (HDI which is a development indicator based on life expectancy, adult literacy and GDP; Table 2.8), the districts in eastern areas of the country receive higher rankings (i.e., Jhapa, Morang, and Chitwan districts), with the exception of Sarlahi district where Lakhandei river flows. On the other hand, those located toward the west (i.e., Bardiya, Dang and Kailali) exhibit relatively low performance in human development.

(4) Implications for Flood Mitigation

The Terai plain has much higher rate of the population growth, due to the inflows of the migrants from the mountain/hill areas who seek for livelihood improvements. This in-migration has been absorbed mainly by clearing land adjacent to the rivers. The following table shows a summary of annual population growth rate (1981-1991) for

respective river basins and districts concerned:

(Population Growth Ratio)

River	District total (%)	Flood-prone areas (%)
1.Ratuwa	2.3	1.9
2.Lohandra	2.3	3.3
3.Lakhandei	2.1	5.7
4.Narayani	3.4	6.3
5.Tinau	3.2	7.0
6.West Rapti	3.1	6.7
7.Babai	3.8	3.7
8.Khutiya	4.8	8.4

As the above table shows, when compared with the district-wise population trends, it is clear that human settlements are increasingly expanding into flood-prone areas along most of the eight rivers.

While the Terai has a high agricultural productivity (often called "granary of Nepal"), it is a predominantly agrarian society. As mentioned in the previous section, only 5 % of the labor force in the 10 target districts is engaged in manufacturing, while only 14 % in service sectors. Given the lack of opportunities in non-agricultural sectors, a majority of the population residing in the flood-prone areas engage in agriculture, despite the fact that their crops (mainly paddy and maize) are liable to flooding.

Figure 2.9 captures various social and economic factors that exacerbate flood disasters in the Terai. As the figure indicates, larger social and economic forces are operating to cause the "expansion of the human settlements" in the river basins and the "proliferation of agriculture" in the flood plains. It will therefore be daunting tasks to attempt to prohibit the people from living in the flood-prone areas, and to prevent more people from further migrating into the flood-prone areas.

A more realistic and attainable approach is to assist the people living in the river basins, to adjust to and cope with flooding, instead of attempting to regulate human settlements in the flood plains. Accordingly, the flood mitigation Master Plan for the Terai plain will place emphasis on enhancing "local preparedness" and "social protection" (both of which are shown in the above figure) with a view to promoting "living with floods" strategies.

2.5 River and Basin Conditions

2.5.1 River Systems in Nepal

Major river systems and their principal features are shown in Fig. 2.10 and Table 2.9. Nepal is drained mainly by four major rivers. They are, from east, the Kosi, Narayani (Gandaki), Karnali and Mahakali rivers. The major four river basins share about 71 % of the total area of Nepal. Other individual rivers originating from the Mahabharat ranges include the Kankai, Kamala, Bagmati, Tinau, West Rapti and Babai rivers.

Aside from the above, numerous rivers of small scale originate from the Siwalik hills, among which included are the Ratuwa, Lohandra, Lakhandei and Khutiya rivers selected for the present study.

All of these rivers, running in a southeast direction in the Terai plain, flow into the Ganges river in India. The Ganges river finally empty into the Bay of Bengal passing through Bangladesh. Since all rivers in the Terai plain flow into India, any modifications to rivers in Nepal influence the flow conditions in India.

Mainly based on the origin and size of the basin, rivers in the Terai plain are classified into three as follows:

1) **Class I:** Rivers flowing from the Himalayas and Tibet with large basin area. They are the Kosi, Narayani, Karnali and Mahakali rivers.
2) **Class II:** Rivers originating in the midlands or in Mahabharat ranges with medium basin size. They are the Kankai, Kamala, Bagmati, Tinau, West Rapti and Babai rivers
3) **Class III:** Rivers coming from southern slope of the Siwalik hills and Mahabharat ranges with smaller basin size. There are numerous river basins. The Ratuwa, Lohandra, Lakhandei and Khutiya rivers for the present study fall under this class.

2.5.2 River Basins and River Channels in Study Area

(1) River Basin

General basin maps of the eight rivers are shown in Fig. 2.11 with their schematic river systems. The basin maps were prepared based on the topographic maps of scale

1/25,000. Topographic maps of 1/25,000 for the western part of Nepal are under preparation in Department of Survey and are not yet available. Topographic maps of 1/50,000 were used to prepare overall basin maps of the West Rapti, Babai and Khutiya rivers. Lower basins of the West Rapti and Babai rivers were prepared based on the draft topographic maps of 1/25,000. Aerial photos of approximately 1/50,000 were used for the lower Khutiya river, since the topographic maps were not available for both scales of 1/25,000 and 1/50,000.

Boundaries of the river basin and sub-basins were drawn on the basin map. Basin boundary in the Terai plain was delineated taking into consideration the existing drainage channels, irrigation canals, road networks and other objects. The basin area of each river is shown in Table 2.10 and summarized below.

(Mountain and Plain Areas)

River	Mountain (km^2)	Plain (km^2)	Total (km^2)
Ratuwa R.	133	250	383
Lohandra R.	140(31)	279	419(310)
Lakhandei R.	106	194	300
Narayani R.	35,075	705	35,780
Tinau R.	669	412	1,081
West Rapti R.	5,800	618	6,418
Babai R.	3,054	371	3,425
Khutiya R.	175	150	325

(Note) Areas in ( ) of the Lohandra river indicate those excluding mountainous basin of the Chisan river.

(2) Channel Characteristics

The slope and width of the existing river channel are shown in Fig. 2.12. Since river survey data were not available, these were prepared mainly based on the topographic map and aerial photos.

In order to clarify the slope of existing river, ground elevation along the river course was plotted, based on the spot elevation data on the topographic maps of 1/25,000. The river width was measured at the intervals of 1 km along the river, based on the topographic maps. The river width includes perennial river sections and sand bars in the meandering and braided river section drawn on the maps.

According to the Figures, basic features of the existing rivers from the Indian border to the upper end of the Terai plain are summarized below.

(Basic Channel Features)

River	Class	Length(km)	Slope	Width(M)
Ratuwa R.	III	43.7 (33.4)	1/170～1180	200～690
Lohandra R.	III	67.5 (51.9)	1/80～2000	50～520
Lakhandei R.	III	51.4 (40.9)	1/240～1240	50～900
Narayani R.	I	83.0 (80.6)	1/720～1/1560	400～2500
Tinau R.	II	59.5 (57.7)	1/110～3180	100～940
W. Rapti R.	II	53.0 (163.5)	1/540～1920	200～1700
Babai R.	II	48.0 (48.0)	1/320～3000	200～1300
Khutiya R.	III	35.0 (28.6)	1/70～2130	50～650

(Note) River length in ( ) indicates that downstream from East-West Highway.

(3) River Course Shifting

It is said that rivers in the Terai plain have a tendency to shift westwards. If this is true the existing thalweg must be closer to the west or right side bank as a whole. Under this hypothesis, the location of thalweg in the river section was measured at every 1 km and shown in Fig. 2.12. As a result, clear tendency of westward shifting was not seen for any of the rivers subject to the Study.

In order to look into the actual shifting of river course in the past, old topographic maps of scale:1/50,000 and new maps of scale:1/25,000 were superimposed. The river course in the old maps are prepared based on the aerial photos taken in 1954, and that in new maps is in 1992 for the eastern five rivers and in 1996 for the western three rivers.

According to the river course changes during the past 38 or 42 years, the following features are found:

1) River course is rather straight in the upper braided bed reaches and the erosions occur within a limited river zone.
2) Meandering of river course becomes active in the lower reaches. But the meandering seems to remain within the meandering belt.
3) Larger shifting of river course is only seen in the West Rapti and the Babai rivers.

2.6 Basin Development Projects and Plans

Sunsari Morang Irrigation Project/ Lohandra River: The Sunsari Morang Irrigation Project (SMIP) was originally implemented as Chatra Canal Project (CCP) under the grant aid from the Government of India (1964 – 1975). The SMIP has been rehabilitated since 1978 by the financial assistance of International Development

Association (IDA). The rehabilitation is implemented in three stages under the name of Sunsari Morang Headwork Project (SMHP) as follow:

1) Stage-I: Development of the Shankarpur Distributary and its adjacent area (9,750 ha) including the Koshi river control and sediment control device. (April 1978 – June 1986).
2) Stage-II: Development of the Sitagunj and Ramgunj Distributaries area (16,600 ha) including improvement of Chatra Main Canal (CMC) and related structures (November 1988 – July 1994).
3) Stage-III: Development of the remaining command area (46,000 ha) under a phased implementation program including improvement of CMC, related structures, and other required improvement works for the Stage-I & II areas. Feasibility Study was completed in June 1995.

Bagmati Irrigation Project/ Lakhandei River: Bagmati Irrigation Project draws water from the barrage situated in Karmaiya, Sarlahi. The barrage is situated about 500 m upstream of the east-west highway bridge crossing the Bagmati river. The project area lies administratively in two Terai districts of Sarlahi and Rautahat in the Central Development Region. Construction works of the project were initiated in 1979 utilizing HMG/N's own resources. At latter stages, some amounts of grants/loans have been received from UNDP, Saudi Fund for Development (SFD) and Debt Relief Fund. Efforts have been concentrated at present to make use of the available natural flow in the shortest possible time to provide irrigation for 37,000 ha. The project has suffered from substantial delays in works due to the unprecedented flood of July 1993.

Bhairahawa Lumbini Groundwater Project/ Tinau River: The Bhairahwa Lumbini Groundwater Project (BLGWP) comprises the following stages:

1) Stage I: The work was implemented during the years from 1978 to 1983, covering a target area of net 7,680 ha. The actual cultivated control area (CCA) is 7,235 ha.
2) Stage II: The work was implemented during the years from 1983 to 1991, consisting of 2 Phases, with target areas of 1,850 ha for Phase 1 and 2,750 ha for Phase 2. The actual CCA for Phase 1 and 2 is 1,218 ha and 2,755 ha, respectively.
3) Stage III: The work started in 1991 covering 8,600 ha and is scheduled for completion at the end of June 1998. The actual CCA is 8,579 ha.

Sikta Irrigation Project/ West Rapti River: The proposed project area lies in the Banke District of the Mid Western Development Region of Nepal. The project area extends in the west right down to the India border. In the project area, Nepalganj is the main town which is the district capital as well as zonal headquarter of Bheri Zone. In this project, a head-works (barrage) will be constructed on the West Rapti river near Agaiya village, to irrigate net 36,070 ha of land with canals on both banks. The area to be irrigated by the right canal system is 34,270 ha between Mand and Dundwa rivers. Irrigation area on the left bank is 1,800 ha (net).

Babai Irrigation Project/ Babai River: Construction of the Babai Irrigation Project is planned in three phases as follows:

1) 1st Phase: Construction and development of command area (13,240 ha) on right bank of the Babai river.
2) 2nd Phase: Construction and development of command area (5,760 ha) on left bank as well as that (21,000 ha) on right bank of the Babai river. The works of the 2nd phase will be implemented after 35 m^3/s discharge is diverted to the Babai River from the Bheri River by Bheri-Babai Diversion Project.
3) 3rd Phase: Construction and development of additional command area (32,000 ha) on left bank of the Babai river when 60 m^3/s discharge is diverted to the Babai River from the Bheri River.

The project is suitably located and configured for incorporation into the Bheri-Babai Multipurpose Project.

Bheri-Babai Diversion Scheme/ Babai River: Bheri-Babai Diversion Project has been conceived as a diversion scheme with a 35-m high dam at the Bheri river and underground power house near Bheri river with a generating capacity of 83 MW. The 9-km long tailrace tunnel discharges the water to the Babai river about 20 km upstream of the existing Babai Irrigation Project. The Bheri diversion water (tentatively 60 m^3/s) along with the Babai discharge would be sufficient to irrigate the command area of 74,000 ha in Bardiya and Banke districts.

Existing Hydropower plants: There exist nine major hydropower plants over the country of Nepal. Out of these 6 plants (136.5 MW in total) are located in the Narayani river, while others are in the Sunkosi and Bagmati rivers as listed below.

(Existing Hydropower plants)

Plant	Proposed capacity (MW)	River
Panauti	2.4	Sunkosi R.
Trisuli	21.0	Narayani R./Trisuli R.
Sunkosi	10.0	Sunkosi R.
Gandak	15.0	Narayani R.
Kulekhani No.1	60.0	Bagmati R.
Devighat	14.1	Narayani R./Trisuli R.
Kulekhani No.2	32.0	Bagmati R.
Marsyangdi	69.0	Narayani R./Marsyangdi R.
Andi Khola (BPC)	5.1	Narayani R./Kaligandaki R.
Jhimruk (BPC)	12.3	Narayani R./Kaligandaki R.
Total	240.9	

Medium Hydropower Project: NEA has conducted Phase-I study of Medium Hydropower Study Project with an aid of Canadian International Water and Energy Consultants. The medium hydropower is defined as those ranging from 10 to 300 MW. In this study, a total of 138 sites were inventoried. Through the several stages of screening, 7 priority sites were selected as follows:

(Priority Sites for Medium Hydropower Project)

Plant	Installed capacity (MW)	River
Upper Karnali (KR-1A)	240	Karnali R.
Dudh Koshi (DD-1)	134	Sunkosi R.
Kabeli A (KB-A)	35	-
Likhu Khola (LK-4)	34	Kamala R.
Rahughat Khola (RH-0)	24	Narayani R.
Budhi Ganga (BG-0)	22	Karnali R.
Tamur (TM-3)	72	-

2.7 Institutional Setting

2.7.1 Policy Framework

Approach to the Ninth Plan (1997-2002): The Government of Nepal has only formulated an overall "Approach to the Ninth Plan (1997-2002)", and is currently in the process of finalizing the detailed Five-Year Development Plan. The Approach Paper emphasizes the need for a more comprehensive approach to river training, as follows:

> "River control program shall be coordinated with agriculture, forestry, and soil conservation programs to make it more effective and its scope of works shall gradually be expanded (excerpts of Approach to the Ninth Plan)."

National Action Plan on Disaster Management: The "National Action Plan on

Disaster Management" has been prepared by the National Committee, which was constituted as part of the UN's call for the "International Decade for Natural Disaster Reduction (IDNDR)". The Plan specifies (1) priority activities to be undertaken in the fields of disaster management (including flood mitigation), (2) responsible agencies, and (3) time periods for completion. The following table shows the Plan's priority activities and responsible agencies that have implications on this Master Plan.

(Priority Activities of National Action Plan)

Priority Activity	Executing Agency (Cooperating Agency)
Policy on Flood Mitigation	Min. of Water Resources
Flood Hazard Map	Dept. of Hydrology & Meteorology (Dept. of Irrigation, DPTC)
Awareness Raising	Min. of Info. & Communications Min. of Education & Culture (Min. of Home, Nepal Admin. Staff College)
Training/ Rehearsal /Simulation	District Disaster Relief Committee Nepal Red Cross Society (Local NGOs)
Flood Forecasting & Warning	Dept. of Hydrology & Metereology (Dept. of Irrigation, DPTC)
Land Use & Land Cover Plan	Min. of Land Reform & Management (Min. of Water Resources, Min. of Forest & Soil Conservation)

Draft River Training Policy: Realizing the need for a clear-cut policy framework, the DOI has developed a draft "River Training Policy" which would serve as a basis for MOWR to further develop flood mitigation strategies. However, as indicated above, the Policy is yet to be reviewed within the MOWR for formal approval.

The draft Policy, as formulated to date, emphasizes the need for a more comprehensive approach through (1) use of local materials instead of relying solely on gabion wires, (2) incorporation of bio-engineering in river training facilities, (3) combination of structural and non-structural measures, and (4) capacity-building of community organizations for flood mitigation. The draft Policy also stresses the need for a more systematic approach to river training in the Terai, through the establishment of river classifications, design criteria, and data base.

Watershed Development Policy: On the other hand, the Government has already endorsed a policy concerning upper watershed conservation. The natural erosion in the hills and the mountains is being accelerated by human activities (e.g., deforestation,

and inappropriate land use including farming). The major thrust of the "Watershed Development Policy" is to help people meet their basic needs, by improving land and increasing agricultural productivity through proper conservation and utilization of watershed resources.

The Policy stresses integrated watershed management, linking forestry, agriculture, livestock, water, and land use, to help people better conserve and manage land and water resources. An attempt to achieve such integrated conservation without securing people's participation and cooperation will be futile. The Policy therefore places emphasis on mobilizing people, as well as raising their awareness, to implement conservation measures through user groups.

2.7.2 Organizations Involved in Flood Mitigation

(1) Department of Irrigation (DOI, MOWR)

The Ministry of Water Resources (MOWR) oversees one of the most crucial factors of the country's development, i.e., water. In Nepal, water resources play a vital role for irrigation, drinking, and power generation purposes. At the same time, water can also be destructive and endangering human lives and properties. To assume tasks of managing water resources, there are four major offices within MOWR, the Department of Irrigation, the Electricity Development Committee, the Policy & Planning Division, and Program & Evaluation Division (Fig. 2.13).

The Department of Irrigation (DOI) is responsible for flood mitigation. The DOI consists of five major divisions (Fig. 2.14), i.e., the Planning, Design, Monitoring & Evaluation Division; the Surface Water Irrigation Division; the Groundwater Irrigation Division; the Flood Control, Environmental & Mechanical Division; and the Irrigation Management Division. The DOI has District Irrigation Offices (DIOs) in all 75 districts which are coordinated by 5 Regional Irrigation Offices (RIOs). There are about 600 DOI staff members (80 at the national level, 50 at the regional level, and 470 at the district level).

The DOI manages its river training portfolio through its Flood Control, Environmental & Mechanical Division (FEMD). There are two types of projects for river training, i.e. national-level and local-level projects. The FEMD directly operates national-level river training projects from the DOI headquarters, while local-level projects are handled through DIOs at the district level.

National-level River Training Projects: As of March 1998, the DOI operates six national-level undertakings for river training as follows (Table 2.11):

1) Rajapur Irrigation Project
2) East Rapti Irrigation Project
3) Bagmati River Training Project
4) Banganga River Training Project
5) Extension of Right Embankment along Lalbankeya
6) Bakra Flood Protection Project

Local-level River Training Projects: Unlike national-level projects which come under the Department's direct control, the DOI is required to implement its local-level flood mitigation activities, through the DIO and the District River Training Coordination Committee (DRTCC). As shown in Fig. 2.15, the DRTCC is headed by the District Development Committee (DDC) chairman, with its members drawn from major political parties, as well as district-level representatives of the Ministry of Local Development (Local Development Officer), and the Ministry of Home (Chief District Officer). The DIO chief serves as a member-secretary to the DRTCC.

Under this "decentralized" arrangement, the DDC and VDC encourage local residents to submit requests to the DRTCC. Requests from different parts of the district are accumulated into a district-wise list which the DRTCC scrutinizes when planning river training activities. This bottom-up procedure is intended to link the DOI's resources with local demands and priorities for river training facilities.

The DOI's budget and manpower are shown in Table 2.12. The table clearly shows the lack of fund and manpower

(2) Water-Induced Disaster Prevention Technical Training Center (DPTC)

The Water-Induced Disaster Technical Training Center (DPTC) was established in 1991, as a joint undertaking of various concerned HMG agencies with the MOWR as the leading agency. The objective of the DPTC is to strengthen the capabilities of the Government of Nepal to cope with water-induced disasters. The DPTC undertakes training activities, as well as development of technology and database, in the fields of (1) Sabo (land erosion control), (2) landslide prevention, and (3) river training.

(3) Department of Soil Conservation and Watershed Management (DOSCWM)

The Ministry of Forest and Soil Conservation (MOFSC) is composed of five major divisions, i.e., the Department of Forest, the Department of Soil Conservation and Watershed Management, the Department of National Parks, the Department of Plant Resources, and the Forest Survey and Research Center. Of direct relevance to the flood mitigation is the Department of Soil Conservation and Watershed Management (DOSCWM).

The DOSCWM, with an increasing number of branch offices in the Terai plain, also contributes to the flood mitigation through soil conservation which is also a crucial factor in promoting flood mitigation in the Study Area. The DOSCWM is the main implementing agency of "Watershed Development Policy". In line with the Policy's principles of "integrated approach" and "people's participation", the DOSCWM has a broad mandate of helping people to implement proper management of watershed resources, and to meet their basic needs for forest and food products through enhanced land and agricultural productivity.

(4) Ministry of Local Development

The Ministry of Local Development (MLD) is responsible for formulating strategies and legislation on local development, and also for assisting in institutional development of local governments. The MLD is also involved in river training, not as a direct implementing agency, but as an organization to promote the roles of local governments in infrastructure provisions including river training.

To fulfill this responsibility, the MLD has been coordinating the Rural Community Infrastructure Works (RCIW) Program. The RCIW provides technical, financial, and material support for selected communities in 20 districts, to construct small-scale infrastructure.

(5) Local Government Institutions (LGIs)

In Nepal, there are 75 districts, 3,912 villages and 58 municipalities. These administrative units are headed by elected representatives, who form development committees (which serves both as executive and deliberative organs) at each level, namely, the District Development Committee (DDC), the Village Development

Committee (VDC), and Municipality.

Under the present decentralization strategy, these local governing institutions (LGIs) are responsible for coordinating development activities in their own jurisdictions. As indicated by the experiences of the efforts for small-scale infrastructure development by the MLD, the Local Governing Institutions (LGIs) can play a significant role in facilitating community mobilization and also in coordinating different organizations operating in their own jurisdictions.

(6) External Support Agencies

The UNDP-supported UN Disaster Management Secretariat (UN-DMS) is housed within the UNDP Country Office and assists in coordinating international response to disasters including floods. During emergency periods, the UN-DMS acts, as an information-clearing house, receiving and disseminating situation reports, needs assessments, donor pledges, and other pertinent information, to facilitate coordination of emergency operations by different government agencies and donors.

Non-Governmental Organizations (NGOs): There exists an NGO-led Disaster Preparedness Network (DPNET), an association of organizations concerned with community-based disaster management. The DPNET can participate in implementing community development components of the flood mitigation plan.

(Further in-depth descriptions on the topics of this chapter are compiled in SUPPORTING REPORT B: OVERALL DESCRIPTIONS OF STUDY AREA.)

SUMMARY OF METEOROLOGICAL CONDITIONS

No.	Station Code	Station Name	Type of Station	District	Latitude N	Longitude E	Elevation (m)	Mean Monthly Maximum Temperature (°C)	Mean Monthly Minimum Temperature (°C)	Mean Monthly Relative Humidity (%)	Mean Annual Rainfall (mm)	Maximum Mean Monthly Rainfall (mm)		Remarks
1	0209	Dhangadhi	Climatology	Kailali	28°41'	80°36'	170	30.6	17.3	79.6	1,648.0	525.2	Jul	Khutiya Basin
2	0215	Godavari (West)	Climatology	Kailali	28°52'	80°38'	288	30.2	19.8	74.8	2,279.4	700.1	Jul	Khutiya Basin
3	0218	Dipayal (Doti)	Synoptic	Doti	29°15'	80°57'	617	30.7	14.8	77.9	1,078.8	249.0	Jul	
4	0402	Dailekh	Climatology	Dailekh	28°51'	81°43'	1,402	23.7	12.9	73.9	1,743.9	483.6	Jul	
5	0406	Surkhet (Birendra Nagar)	Synoptic	Surkhet	28°36'	81°37'	720	27.9	15.5	75.8	1,569.3	474.0	Jul	
6	0416	Nepalgunj (Rep.Off.)	Climatology	Banke	28°04'	81°37'	144	30.9	19.2	82.7	1,337.6	425.8	Jul	West Rapti Basin
7	0417	Rani Jaruwa Nursery	Climatology	Bardiya	28°23'	81°21'	200	30.9	17.9	82.7	1,279.1	370.2	Jul	Babai Basin
8	0508	Tulsipur	Climatology	Dangdekhuri	28°08'	82°18'	725	28.8	16.6	78.5	1,458.1	402.9	Aug	Babai Basin
9	0601	Jomsom	Climatology	Mustang	28°47'	83°43'	2,744	17.8	4.9	63.6	212.6	40.9	Jul	
10	0612	Mustang (Lomangtang)	Climatology	Mustang	29°11'	83°58'	3,705	12.5	-1.3	82.9	118.3	45.0	Jul	
11	0702	Tansen	Climatology	Palpa	27°52'	83°32'	1,067	25.1	15.1	80.1	1,677.0	477.1	Jul	Tinau Basin
12	0705	Bhairhawa Airport	Agrometeology	Rupandehi	27°31'	83°26'	109	30.9	18.4	79.7	1,608.9	508.6	Jul	Tinau Basin
13	0706	Dunkauli	Agrometeology	Nawalparasi	27°41'	84°13'	154	30.7	18.6	82.9	2,216.8	641.0	Jul	Narayani Basin
14	0804	Pokhara Airport	Agrometeology	Kaski	28°13'	84°00'	827	26.5	15.2	80.9	3,786.9	928.9	Jul	Narayani Basin
15	0809	Gorkha	Agrometeology	Gorkha	28°00'	84°37'	1,097	25.9	15.7	79.5	1,683.9	408.7	Jul	Narayani Basin
16	0906	Hetaunda N.F.I	Climatology	Makwanpur	27°25'	85°03'	474	29.2	16.9	77.9	2,282.9	565.6	Aug	Narayani Basin
17	1030	Kathmandu Airport	Agrometeology	Kathmandu	27°42'	85°22'	1,336	25.3	11.6	85.6	1,347.2	323.9	Jul	
18	1103	Jiri	Agrometeology	Dolakha	27°38'	86°14'	2,003	20.4	8.0	82.7	2,216.9	581.3	Jul	
19	1111	Janakpur Airport	Climatology	Dhanusa	26°43'	85°58'	90	30.6	19.4	75.5	1,474.6	415.0	Jul	
20	1118	Manusmara	Climatology	Sarlahi	26°53'	85°25'	100	31.2	18.7	83.8	1,369.1	416.9	Aug	Bagmati Basin (Lakhandei Basin)
21	1121	Karmaiya	Climatology	Sarlahi	27°07'	85°28'	131	30.7	20.3	75.0	1,718.3	443.1	Aug	Bagmati Basin (Lakhandei Basin)
22	1206	Okhaldhunga	Synoptic	Okhaldhunga	27°19'	86°30'	1,720	20.4	12.8	75.7	1,764.1	469.8	Jul	
23	1307	Dhankuta	Synoptic	Dhankuta	26°59'	87°21'	1,445	21.8	14.5	74.0	1,047.8	232.9	Aug	
24	1319	Biratnagar Airport	Agrometeology	Morang	26°29'	87°16'	72	30.1	18.5	80.4	1,892.8	454.9	Jul	
25	1323	Dharan British Camp	Climatology	Sunsari	26°47'	87°17'	400	28.2	20.3		2,187.3	541.0	Aug	
26	1324	Bhojpur	Agrometeology	Bhojpur	27°11'	87°03'	1,595	20.4	12.5	78.4	1,214.1	258.8	Jul	
27	1405	Taplejung	Synoptic	Taplejung	27°21'	87°40'	1,732	20.4	11.7	77.4	1,961.6	415.0	Aug	
28	1407	Ilam Tea Estate	Agrometeology	Ilam	26°55'	87°54'	1,300	22.4	15.9	76.0	1,787.9	424.0	Jul	
29	1421	Gaida (Kankai)	Climatology	Jhapa	26°30'	87°54'	143	30.3	30.3	76.5	2,852.6	683.2	Aug	

Table 2.1

WETLAND AREA IN TERAI BY LAND-USE TYPE

River	Ratuwa (ha)	Narayani (ha)	Tinau (ha)	W. Rapti (ha)	Babai (ha)	Khutiya (ha)	Total (ha)
Habitation	715	1,900	600	3,800			7,015
Barren	710		600			625	1,935
Agriculture	4,990	9,500	3,400	15,000	1,300	820	35,010
Pasture			600		2,512	1,090	4,202
Grassland		9,500		7,500	2,500		19,500
Open Forest	710	5,700	500		2,600	1,090	10,600
Closed Forest		11,400		11,200	11,200		26,500
Total	7,125	38,000	5,700	37,500	12,812	3,625	104,762

Note: Two of the rivers in the study - Lohandra and Lakhandei do not have designated floodplain areas on them.
Source: IUCN Wetland Database System. IUCN/Nepal 1995.

Table 2.3

PROCEDURE TO FOLLOW UNDER ENVIRONMENTAL CONSERVATION RULES

Step	IEE	EIA	Time Limit (days)
1	Draft Scope of Work (SOW) drawn up for sub-project (SP).		
2	Draft SOW submitted to people affected by SP for comments.		30
3	SOW adjusted , if necessary, to reflect people's comments.		
4	SOW submitted to Ministry of Water Resources (MOWR). MOWR will determine if SP requires an IEE or an EIA.		
5	If SP requires an IEE then MOWR can approve of SOW.	If SP requires an EIA, then SOW submitted to MOPE for approval	
6	After approval, work schedule (WS) drawn up according to Schedule 3 of ECR.	After approval, (WS) drawn up according to Schedule 4 of ECR.	
7	WS submitted for approval to MOWR.	WS submitted for approval to MOPE.	
8	On approval, IEE undertaken according to guidelines laid down in Schedule 5 of ECR.	On approval, EIA undertaken according to guidelines laid down in Schedule 6 of ECR.	
9	Draft IEE report sent to affected people for comments and suggestions.	Draft EIA report sent to affected people for comments and suggestions.	30
10	Final IEE report compiled after considering comments.	Final EIA report compiled after considering comments.	
11	IEE Report submitted to MOWR for approval. If accepted, approval given within 30 days.	Final EIA report sent to MOWR. The MOWR sends to MOPE within 30 days, for approval.	30
12		If acceptable, MOPE will approve the EIA within 90 days of receiving the proposal.	90
13	Once the IEE or EIA approved the sub-project can proceed.		

(Note:)
IEE : Initial Environmental Examination, EIA : Environmental Impact Assessment,
SOW : scope of work, SP : sub-project, MOWR : Ministry of Water Resources,
MOPE : Ministry of Population and Environment, WS : work schedule

SOCIAL AND ECONOMIC SITUATION OF NEPAL

SOCIAL INDICATORS

Year	1970-75	1980-85	1990-95
Population (million)	12.8	16.7	21.5
Annual Population Growth Rate (%)	2.6	2.6	2.5
Income (per capita, US$)	120	160	200
Poverty (% of population)	---	---	42.0
Access to Safe Water (% of Population)	8.0	23.9	44.0
Life Expectancy at Birth (years)	43	49	55
Infant Mortality (per thousand live birth)	160	125	91

Source: World Development Indicators, World Bank, 1997

ECONOMIC DEVELOPMENT DATA

Year	1986-90	1991-94	1995-96
Rate of Growth			
agriculture	4.1	2.0	2.5
non-agriculture	5.5	8.7	5.1
Total GDP	4.8	5.6	4.0
Share of GDP			
agriculture	49.3	44.7	41.5
non-agriculture	50.7	55.3	58.5
- industry	(16.0)	(18.4)	(19.4)
- trade, transport	(16.6)	(17.7)	(19.1)
- other services	(18.1)	(19.2)	(20.0)

Source: Central Bureau of Statistics

LABOUR FORCE STRUCTURE

	Population (million)	% of total
agriculture	15.0	81.2
industry	0.5	2.7
services	3.0	16.1
total	18.5	100.0

Source: Population Census 1991, Central Bureau of Statistics

LAND AREA AND AGRICULTURE PRODUCTION IN 10 TARGET DISTRICTS

Unit: hectares (ton/ha.)

District	Paddy	Maize	Wheat	Pulses	Oilseeds	Sugarcane	Vegetables
Jhapa	104,45 (2.71)	33,625 (1.4)	15,250 (2.05)	3,516 (0.79)	3,012 (0.79)	76 (30.00)	1,515 (7.16)
Morang	97,200 (2.57)	14,000 (1.82)	17,940 (1.70)	6,930 (0.50)	7,900 (1.40)	1,260 (40.0)	2,250 (12.58)
Sarlahi	27,151 (2.35)	9,350 (1.65)	27,000 (1.4)	26,820 (0.60)	5,620 (1.54)	5,500 (33.56)	4,125 (7.09)
Chitwan	45,000 (2.70)	27,127 (2.00)	9,100 (1.70)	---	19,550 (0.75)	40 (27.00)	---
Nawalparasi	46,100 (3.06)	7,700 (2.40)	19,000 (2.36)	7,870 (0.43)	---	7,100 (43.5)	950 (12.00)
Rupandehi	68,000 (1.72)	1,050 (1.72)	20,300 (2.00)	7,400 (0.69)	5,000 (0.69)	3,000 (32.0)	980 (11.31)
Dang	33,500 (3.20)	23,200 2.09	14,100 (2.50)	24,150 (1.03)	18,450 (0.72)	---	1,323 (12.27)
Banke	32,350 (2.48)	7,500 (1.17)	12,899 (1.58)	9,450 (1.09)	8,488 (0.97)	---	3,535 (12.55)
Bardia	33,095 (4.91)	9,920 (2.27)	20,000 (2.25)	12,400 (0.75)	12,250 (0.81)	55 (25)	800 (12.01)
Kailali	51,000 (2.03)	12,017 (1.62)	19,000 (1.46)	---	15,000 (0.62)	300 (29.00)	---
10 Districts	443,841 (3.24)	145,489 (2.76)	174,589 (1.89)	98,536 (0.77)	95,270 (0.76)	17,331 (37.57)	15,478 (10.24)

Source: Annual Agricultural Development Programme 1995/96, District Agriculture Development Office

Upper Figure in the Column: Land Area in ha

Lower Figure in ( ) : Productivity in ton / ha

Shadow : Major three land use.

LAND AREA AND AGRICULTURE PRODUCTION IN 10 TARGET DISTRICTS

Unit: hectares (ton/ha.)

District	Paddy	Maize	Wheat	Pulses	Oilseeds	Sugarcane	Vegetables
Jhapa	104,45	33,625	15,250	3,516	3,012	76	1,515
	(2.71)	(1.4)	(2.05)	(0.79)	(0.79)	(30.00)	(7.16)
Morang	97,200	14,000	17,940	6,930	7,900	1,260	2,250
	(2.57)	(1.82)	(1.70)	(0.50)	(1.40)	(40.0)	(12.58)
Sarlahi	27,151	9,350	27,000	26,820	5,620	5,500	4,125
	(2.35)	(1.65)	(1.4)	(0.60)	(1.54)	(33.56)	(7.09)
Chitwan	45,000	27,127	9,100	---	19,550	40	---
	(2.70)	(2.00)	(1.70)		(0.75)	(27.00)	
Nawalparasi	46,100	7,700	19,000	7,870	---	7,100	950
	(3.06)	(2.40)	(2.36)	(0.43)		(43.5)	(12.00)
Rupandehi	68,000	1,050	20,300	7,400	5,000	3,000	980
	(1.72)	(1.72)	(2.00)	(0.69)	(0.69)	(32.0)	(11.31)
Dang	33,500	23,200	14,100	24,150	18,450	---	1,323
	(3.20)	2.09	(2.50)	(1.03)	(0.72)		(12.27)
Banke	32,350	7,500	12,899	9,450	8,488	---	3,535
	(2.48)	(1.17)	(1.58)	(1.09)	(0.97)		(12.55)
Bardia	33,095	9,920	20,000	12,400	12,250	55	800
	(4.91)	(2.27)	(2.25)	(0.75)	(0.81)	(25)	(12.01)
Kailali	51,000	12,017	19,000	---	15,000	300	---
	(2.03)	(1.62)	(1.46)		(0.62)	(29.00)	
10 Districts	443,841	145,489	174,589	98,536	95,270	17,331	15,478
	(3.24)	(2.76)	(1.89)	(0.77)	(0.76)	(37.57)	(10.24)

Source: Annual Agricultural Development Programme 1995/96, District Agriculture Development Office

Upper Figure in the Column: Land Area in ha

Lower Figure in ( ) : Productivity in ton / ha

Shadow : Major three land use.

LAND OWNERSHIP, AGRICULTURAL LAND AND LAND CULTIVATED/UNCULTIVATED

District	Study River	Owner-Cultivation (%)		Average Holding Size (ha.)		Tenure Arrangement (1991/92) (%)			Terai Agricultural Land (%)	
		1981/82	91/92	1981/82	91/92	Fixed Rent	Share Crop	Others	Cultivated	Non Cultivated
Terai		91.8	87.6	1.47	1.22	30.6	62.7	6.7	91.3	8.7
Jhapa	Ratuwa	89.2	83.6	1.53	1.41	20.9	59.4	19.7	92.8	7.2
Morang	Ratuwa, Lohandra	93.0	79.4	1.34	1.42	22.9	73.1	4.0	91.3	8.7
Sarlahi	Lakhandei	86.8	90.6	1.06	1.14	29.4	52.1	18.5	90.5	9.5
Chitwan	Narayani	97.0	93.4	1.67	0.80	15.3	6.9	77.8	N.A.	N.A.
Nawalparasi	Narayani	98.1	94.7	1.45	1.11	14.5	66.4	19.1	93.7	6.3
Rupandehi	Tinau	99.3	86.4	1.59	1.08	11.9	78.7	9.4	92.9	7.1
Dang	West Rapti	80.4	80.9	1.57	1.17	7.5	89.8	2.7	N.A.	N.A.
Banke	West Rapti	88.5	86.2	1.47	1.37	2.7	94.9	2.4	89.1	10.9
Bardia	Babai	92.2	84.6	2.73	1.61	14.6	82.2	3.2	89.1	10.9
Kailali	Khutiya	97.6	94.4	1.70	1.35	8.8	74.7	16.5	89.5	10.5

source: National Sample Census of Agriculture 1991/92, Department of Agriculture

POPULATION TRENDS IN 10 DISTRICTS

District	Study River	Population in 1991	Population Growth			Population by Caste/Ethnic (1991)		
			1971-81	1981-91	1991-96	Indigenous Groups	Originated from India	Originated from In-Country
Nepal		18,491,097	3.0%	2.3%	2.2%	N.A	N.A.	N.A.
Jhapa	Ratuwa	593,737	6.6%	2.1%	2.2%	14.2%	3.1%	82.7%
Morang	Ratuwa Lohandra	674,823	5.7%	2.3%	N.A	32.3%	8.7%	59.0%
Sarlahi	Lakhandei	492,798	8.2%	2.1%	2.2%	64.6%	10.9%	24.5%
Chitwan	Narayani	354,488	3.5%	3.1%	3.4%	22.0%	---	78.0%
Nawalparasi	Narayani	436,217	7.5%	3.4%	3.8%	54.4%	6.3%	39.3%
Rupandehi	Tinau	522,150	4.4%	3.2%	3.5%	49.7%	17.1%	33.2%
Dang	West Rapti	354,413	4.6%	2.8%	3.1%	51.3%	---	48.7%
Banke	West Rapti	285,604	4.9%	3.3%	3.6%	44.7%	22.9%	32.4%
Bardia	Babai	290,313	5.8%	3.8%	4.1%	64.9%	2.8%	32.3%
Kailali	Khutiya	417,891	6.9%	4.8%	5.5%	57.4%	---	42.6%
10 District	8 Rivers	4,422,434	8.3%	5.0%	2.9%	43.0%	7.9%	49.1%

Source: Population Census 1991, Central Bureau of Statistics

Nepal District Profile, 1997, National Research Associates

N.A: Not available

HUMAN DEVELOPMENT INDEX FOR NEPAL

District	Life Expectancy	Adult literacy ratio(%)	Mean years of schooling	Per capita income (NRs.)	Per capita income (US $)	Life Expectancy Index	Educational Attainment Index	Income Index	Human Development Index(HDI)	Ranking In Country
Morang	66.5	48.45	3.192	7,609	1,176	0.692	0.394	0.178	0.421	4
Jhapa	58.5	54.43	3.511	10,950	1,693	0.558	0.441	0.263	0.421	5
Chitwan	56.5	49.46	2.531	8,414	1,301	0.525	0.386	0.198	0.370	16
Rupandehi	60.5	41.72	2.449	6,807	1,052	0.592	0.333	0.157	0.361	19
Sarlahi	60.5	24.53	1.296	8,330	1,288	0.592	0.192	0.196	0.327	35
Banke	55.5	34.70	2.180	6,061	937	0.508	0.280	0.138	0.309	46
Bardiya	60.5	27.90	1.656	4,424	684	0.592	0.223	0.096	0.304	50
Nawalparasi	53.5	38.38	2.102	5,386	833	0.475	0.272	0.158	0.299	51
Kailali	53.0	34.88	1.767	6,824	1,055	0.467	0.272	0.158	0.299	52
Dang	49.5	38.21	2.150	7,888	1,219	0.408	0.302	0.158	0.299	53

Source: "Nepal Human Development Report", UNDP, 1998

Statistics as of 1996 were used.

MAJOR RIVERS IN NEPAL

	Name of river	Catchment area			Length of main river		
		Total	Area in Nepal		Total	Length in Nepal	
		(km^2)	(km^2)	(%)	(km)	(km)	(%)
1	Koshi River Basin	60,400	27,784	46	534	187	35
1-1	Tamar River	6,125	6,125	100	198	198	100
1-2	Arun River	34,000	5,100	15	481	135	28
1-3	Sunkoshi River	19,220	16,145	84	336	255	76
2	Narayani River Basin	34,960	31,114	89	451	451	100
2-1	Trisuli River	19,700	15,366	78	270	159	59
2-1-1	Budhi Gandaki River	4,960	3,621	73	154	100	65
2-1-2	Marshandi River	4,819	4,819	100	153	153	100
2-1-3	Seti River	2,843	2,843	100	125	125	100
2-2	East Rapti River	2,993	2,993	100	122	122	100
2-3	Kaligandaki River	11,600	11,600	100	316	316	100
3	Karnali River Basin	44,000	41,360	94	550	435	79
3-1	Humla Karnali River	8,500	5,525	65	243	129	53
3-2	Mugu Karnali River	6,155	6,155	100	195	195	100
3-3	Tila River	3,252	3,252	100	109	109	100
3-4	Seti River	7,103	7,103	100	202	202	100
3-5	Bheri River	13,867	13,867	100	264	264	100
4	Mahakali River	15,260	5,188	34	223	223	100
5	Kankai River	1,317	1,317	100	108	108	100
6	Kamala River	1,786	1,786	100	117	117	100
7	Bagmati River	3,681	3,681	100	163	163	100
8	Tinau River	550	550	100	100	100	100
9	West Rapti River	6,215	6,215	100	257	257	100
10	Babai River	3,252	3,252	100	190	190	100

BASIN AREA

River basin	Basin area (km^2)			
	Point	km	Total	Remarks
Ratuwa R.	1	43.7	68	Upper end of plain
	2	19.8	262	Mawa R.
	3	12.2	301	
	4	0.0	383	Border
Lohandra R.	1	67.5	109	Upper end (Chisan R.) of plain
	2	49.6	197	Sukuna R.
	3	33.1	302	Kesaula R.
	4	0.0	419	Border
Lakhandei R.	1	51.4	65	Upper end of plain
	2	39.0	155	Chapani R.
	3	0.0	300	Border
Narayani R.	1	-	16,481	Marsyandi R.
	2	-	19,560	Seti R.
	3	83.0	31,100	Upper end (Gandaki R.) of plain
	4	44.9	34,089	East Rapti R.
	5	18.4	35,780	Narrow
Tinau R.	1	59.5	550	Upper end of plain
	2	12.7	625	Dano R.
	3	12.7	1,065	Dano R. (aft. jct.)
	4	0.0	1,081	Border
West Rapti R.	1	161.5	3,934	Rangsing R.
	2	132.0	4,647	Arjun R.
	3	53.0	5,464	Narrow
	4	23.0	6,125	Jhijhari R.
	5	0.0	6,418	Border
Babai R.	1	48.0	3,002	Barrage
	2	0.0	3,425	Border
Khutiya R.	1	35.0	119	Upper end of plain
	2	11.5	209	Shiva Ganga R.
	2	11.5	309	Shiva Ganga R. (aft. Jct.)
	3	0.0	325	Border

PROFILE OF DOI'S NATIONAL-LEVEL RIVER TRAINING PROJECTS

Project Name	Fiscal Year	Description	Total Budget (Rs.)	Source of Funding
Rajapur Irrigation	1991/92 - 97/98	A irrigation project (15,800 ha. of land in 11 VDCs), with a component for flood control works	204,502,000*	HMG, & Asian Development Bank
East Rapti Irrigation	1992/93 -	A irrigation project (5,200 ha. of land), which includes 18 km long embankment, with some additional river control works	291,888,000*	HMG, & Asian Development Bank
Bagmati River Training	1994/95 - 99/00	Construction of 10 km embankment as well as spurs (also when require, emergency protection works)	79,765,000	HMG
Banganga River Training	1996/97 - 98/99	Construction of 1.5 km length of boulder/earthen bund, with river diversion and channelization work.	28,5000,000	HMG
Extension of Right Embankment along Lalbankeya	1996/97 - 97/98	Extension of embankment (by 9.5 km) along Lanlbankeya river	52,146,000	HMG, & Govt. of India
Bakra River Flood Protection	1997/98 - 99/00	River control covering from foothill to Indian border, with main construction works of 66.5km embankment, 104 spurs, and 14.6 km revetments.	370,000,000	HMG, & OPEC Fund

Source: Dept. of Irrigation

* only budget for river training component

BUDGET AND MANPOWER OF DOI/DIO

(a) DOI's Expenditures: 1988/89-1997/98

(in million Rs.)

Yr.	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98
Dept. Total	976.2	1,015.3	1,189.0	1,460.9	2,165.6	2,494.6	2,204.0	2,772.7	2,577.9	3,040.8 *
Local River Trg.	15.0 (1.5%)	11.1 (1.1%)	12.2 (1.0%)	10.1 (0.6%)	32.4 (1.5%)	28.1 (1.1%)	90.3 (4.1%)	61.2 (2.2%)	44.9 (1.7%)	120.0 * (4.0%) *

Source: Dept. of Irrigation

* proposed figure

(b) District-wise Budget (G.I. Wire) of DOI's Local River Training

in million Rs.(metric tons)

	Jhapa	Morang	Sarlahi	Chitwan	Nawal Parasi	Rupan Dehi	Dang	Banke	Bardiya	Kailali
'96/97	1.9 (167)	1.1 (75)	0.8 (60)	0.4 (55)	1.9 (74)	1.3 (76)	0.2 (67)	0.4 (1.5)	0.8 (50)	0.2 (33)
'97/98	3.3 (32) *	3.1 (25) *	1.4 (5) *	1.3 (22) *	4.1 (15) *	2.7 (20) *	0.6 (10) *	1.5 (10) *	4.4 (6) *	0.8 (8) *

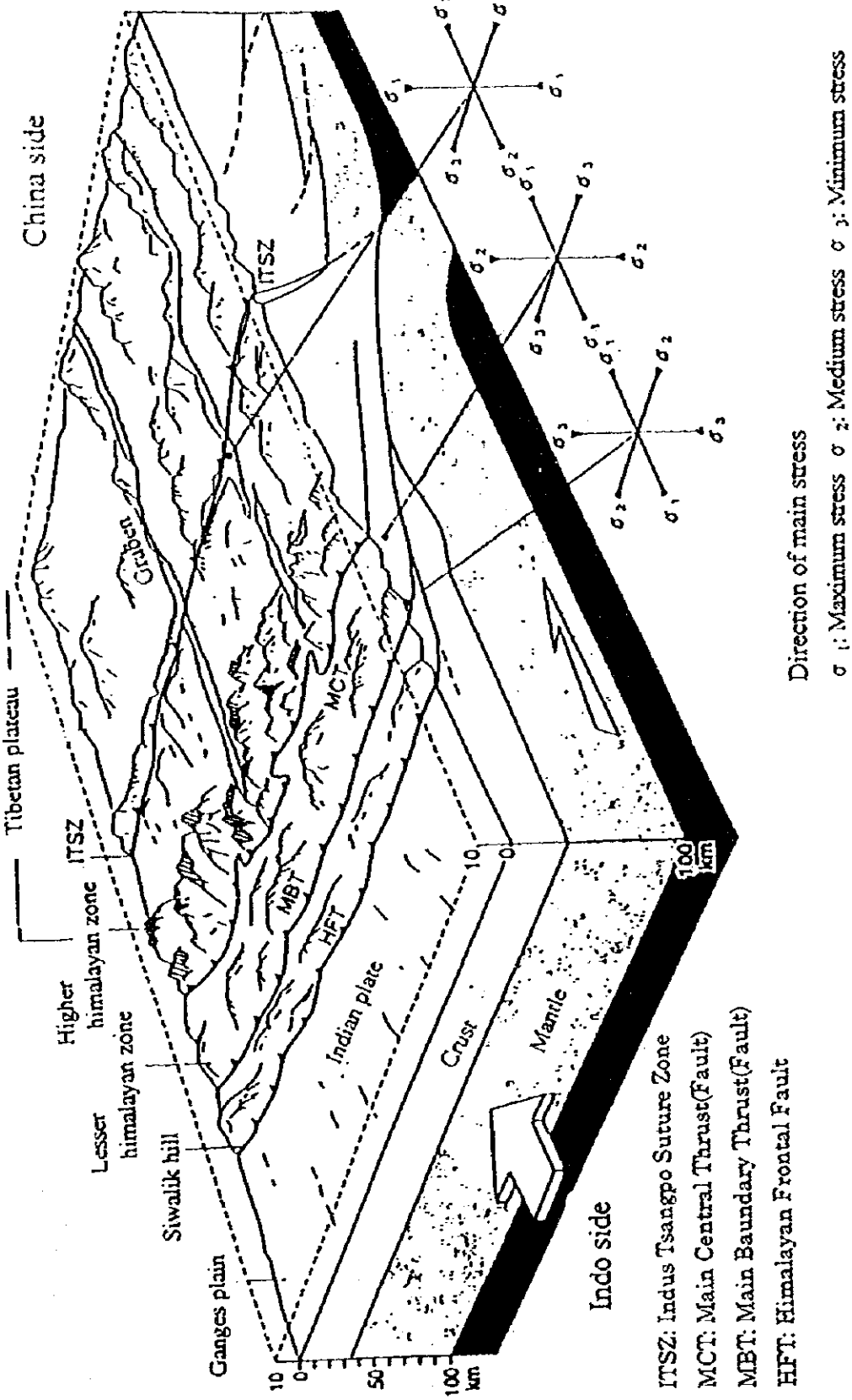
Source: Dept. of Irrigation

* proposed figure

(c) DIO's Personnel in Target Districts (as of March 1998)

	Jhapa	Morang	Sarlahi	Chitwan	Nawal Parasi	Rupan dehi	Dang	Banke	Bardia	Kailali
Chief	1	1	1	1	1	1	1	1	1	1
Engineer	2	4	4	2	1	4	3	2	2	3
Overseer	12	12	7	5	6	7	6	5	5	10
Association Organizer	1	1	1	1	1	1	1	1	1	0

Source: Dept. of Irrigation



GEOMORPHOLOGICAL VIEW OF NEPAL HIMALAYA

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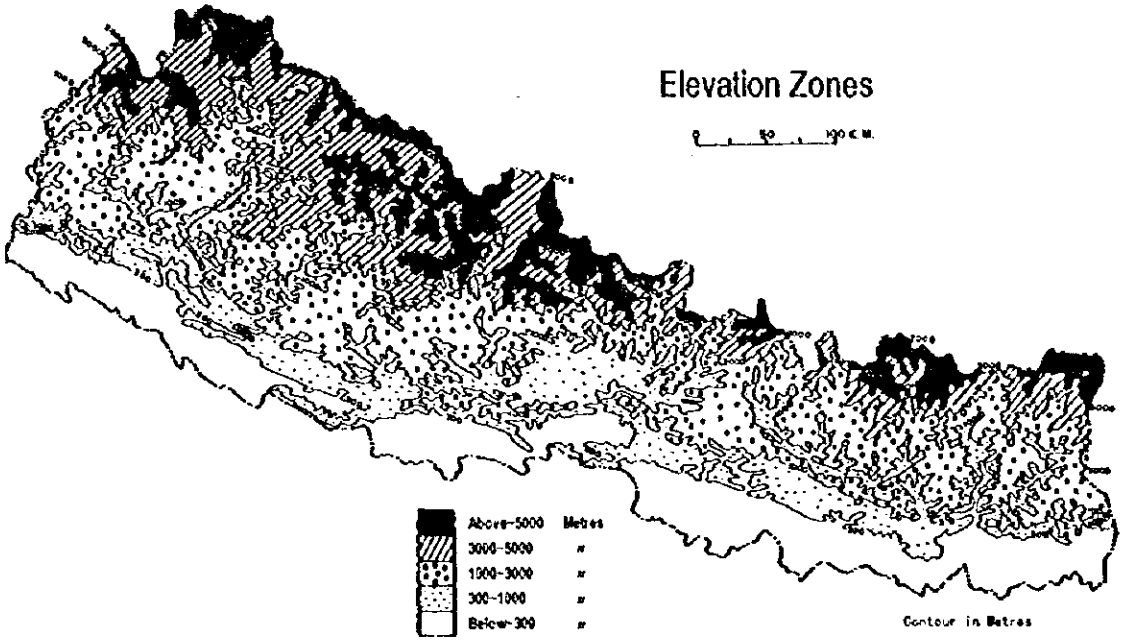
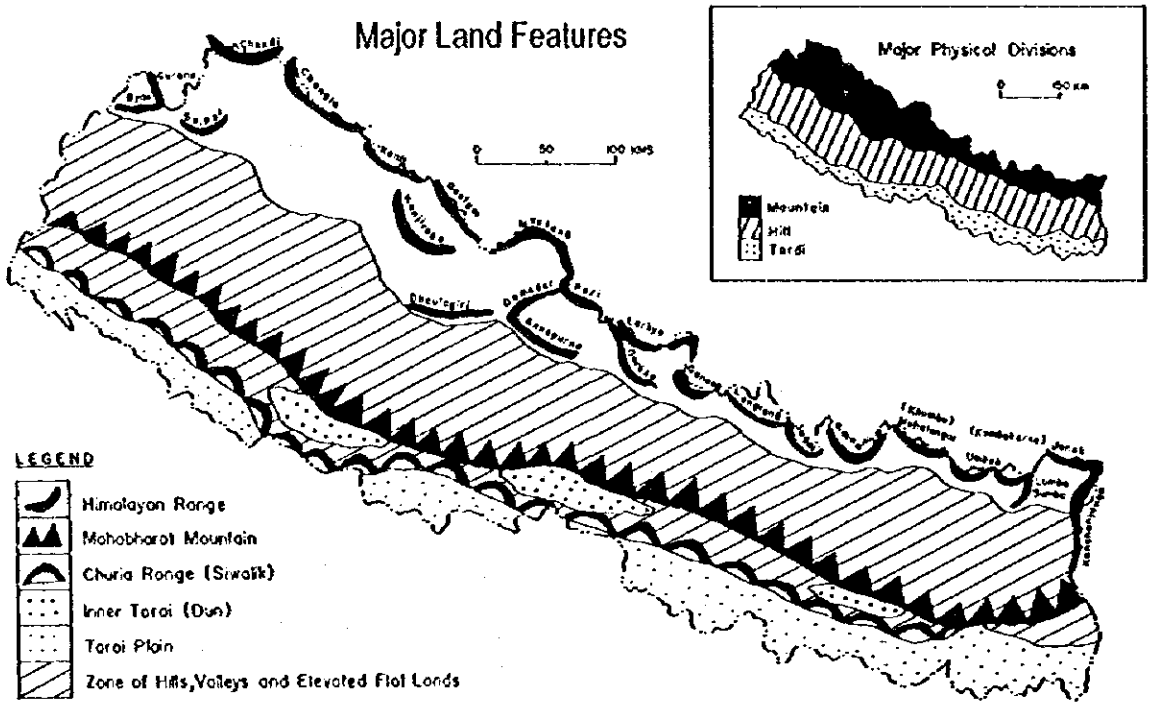
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY





Source: Nepal in Maps, 1988

TOPOGRAPHIC FEATURES

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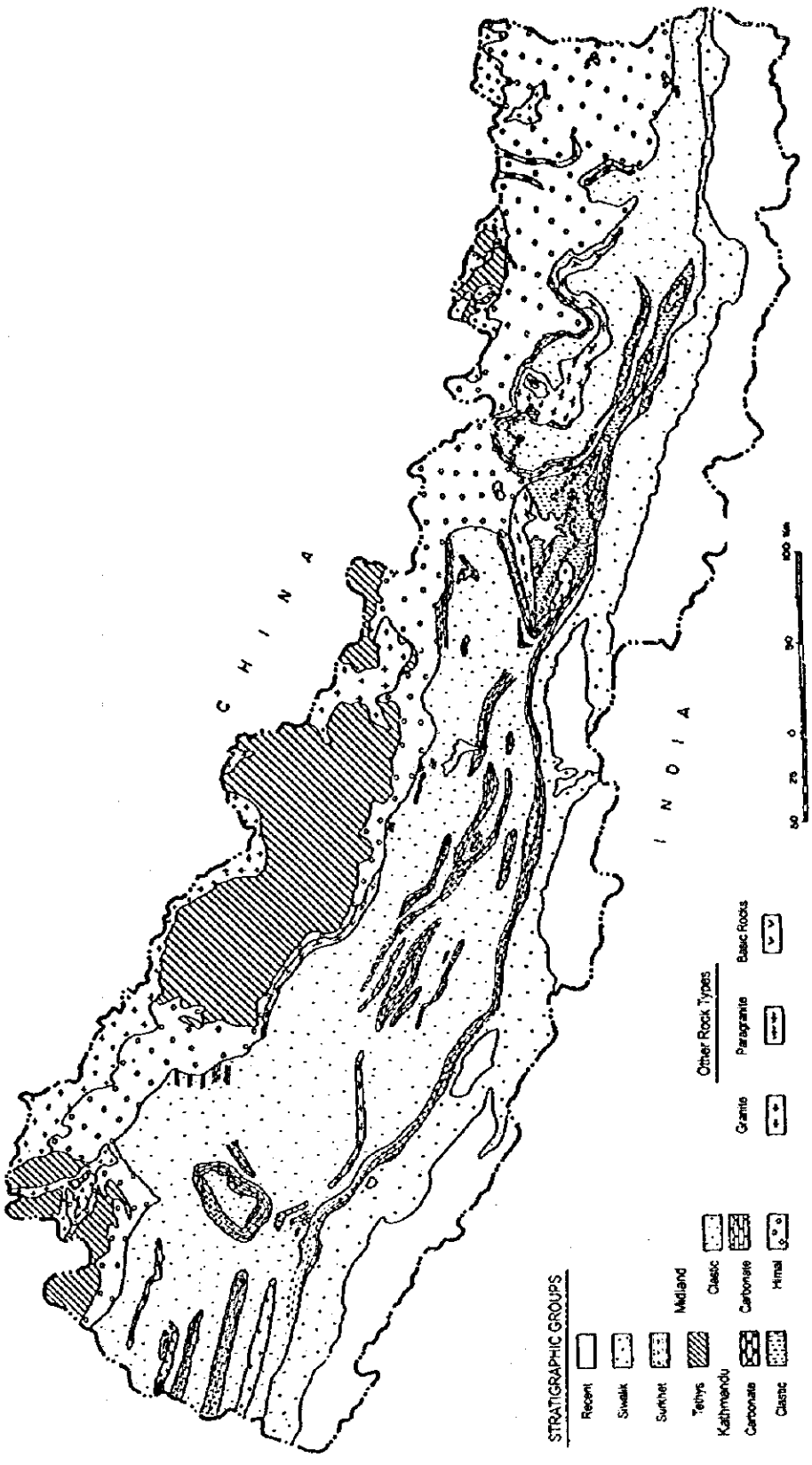
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.3



Source: Nepal in Maps, 1988

GEOLOGY OF NEPAL

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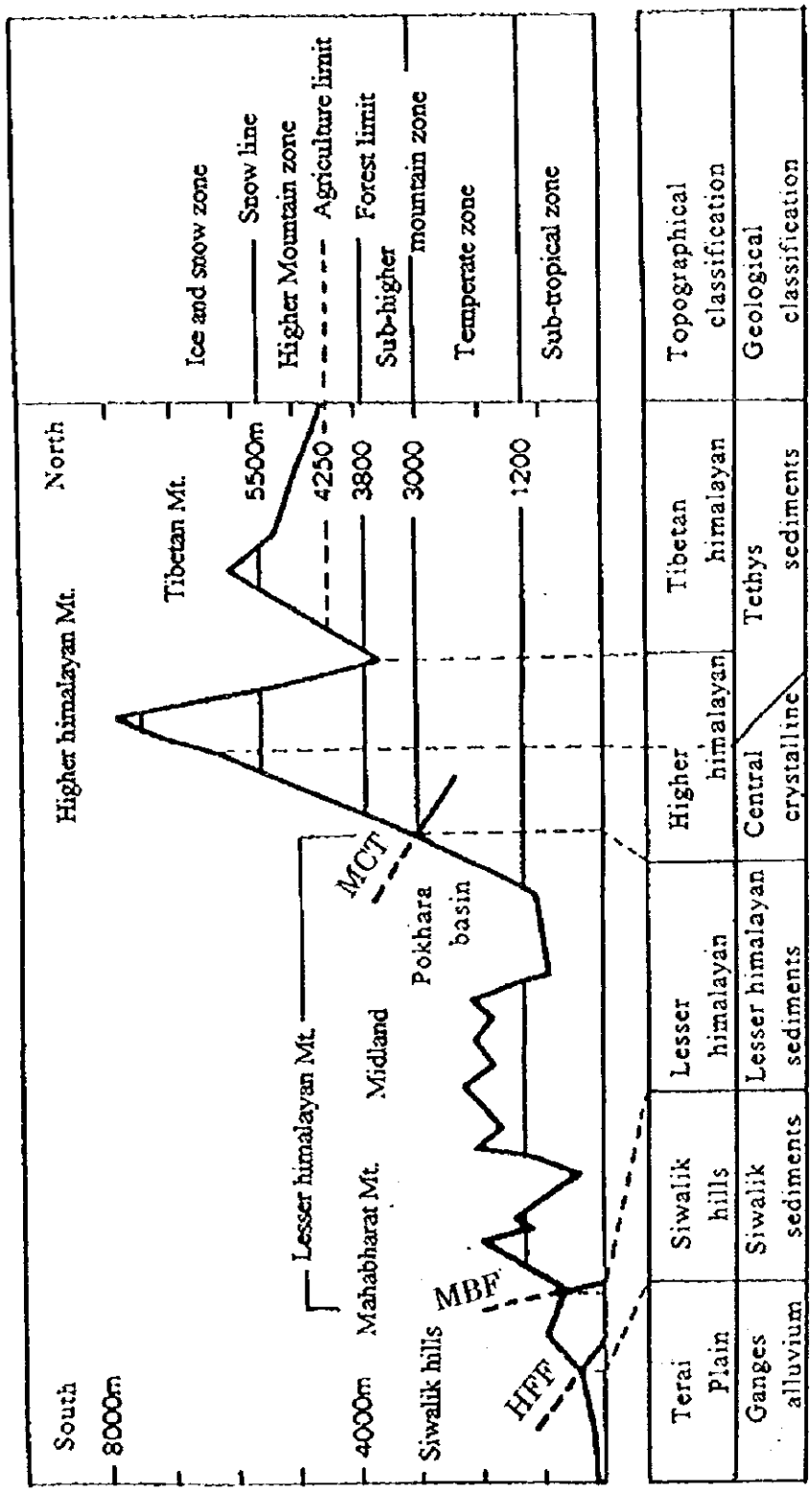
JAPAN INTERNATIONAL COOPERATION AGENCY



TOPOGRAPHICAL AND GEOLOGICAL CLASSIFICATION(N-S PROFILE)

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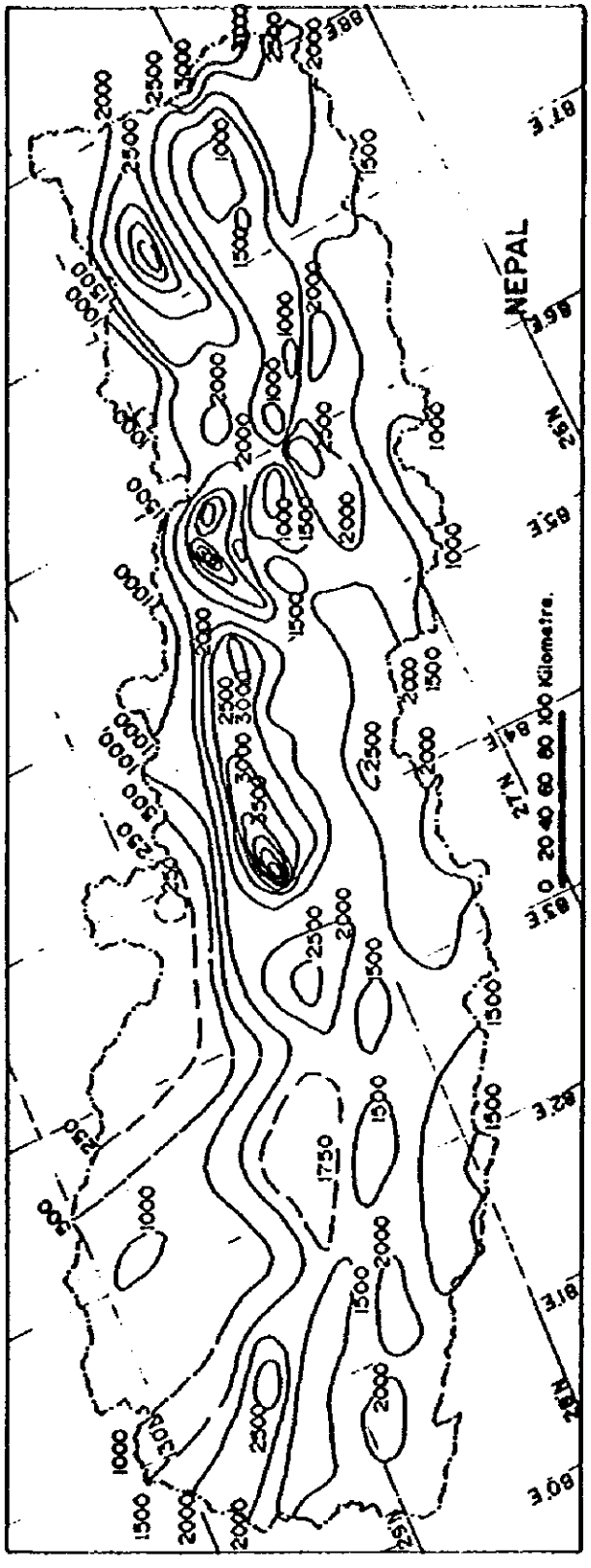
JAPAN INTERNATIONAL COOPERATION AGENCY

MEAN ANNUAL PRECIPITATION (mm) 1971-1985

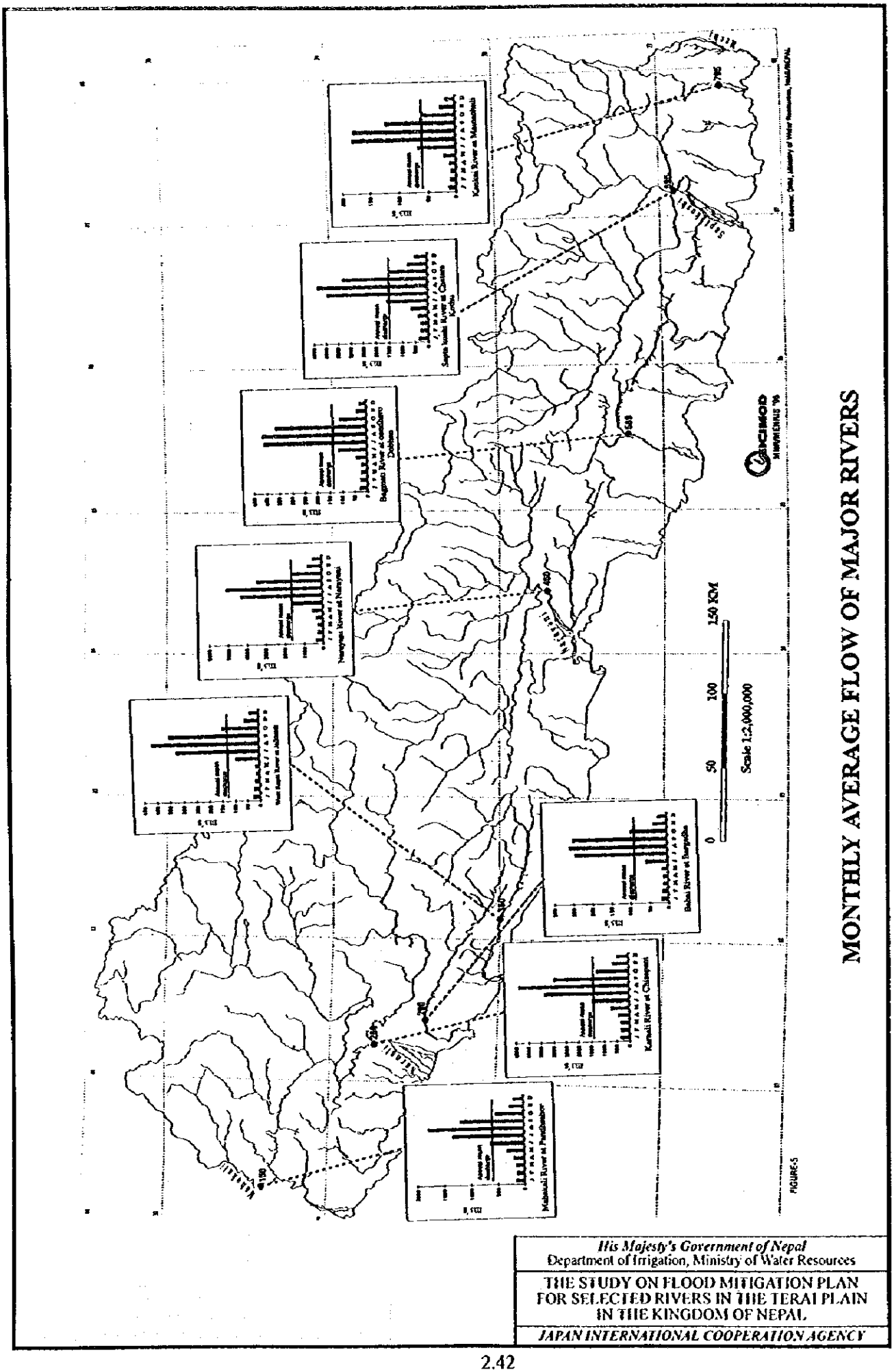


Source: Natural Hazards and Man Made Impacts in The Nepal Himalaya, C.K.Sharman, 1988

ANNUAL RAINFALL DISTRIBUTION OF NEPAL

His Majesty's Government of Nepal Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. 2.6


MONTHLY AVERAGE FLOW OF MAJOR RIVERS
Scale 1:2,000,000
0
50
100
150 KM
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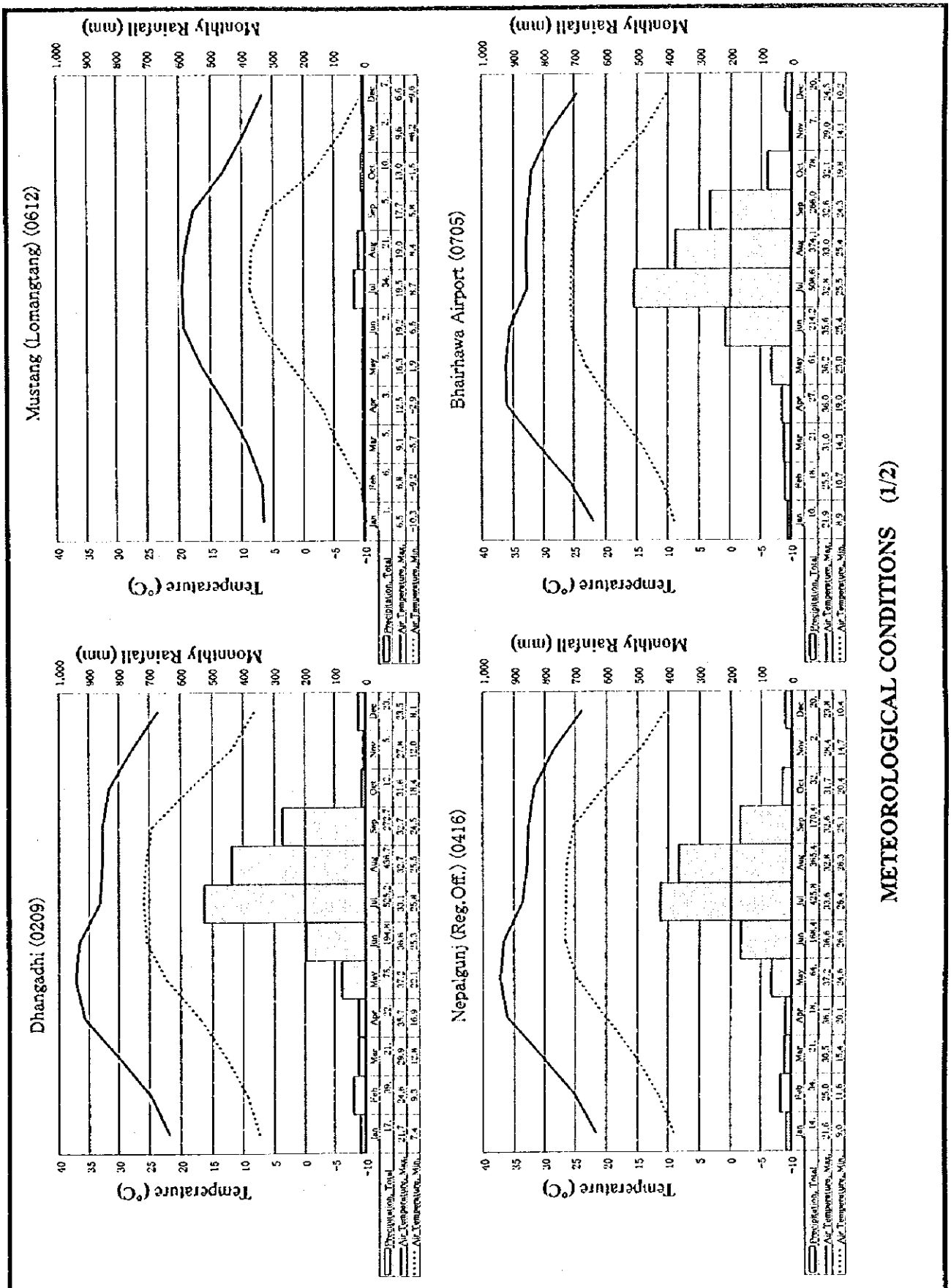
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY



METEOROLOGICAL CONDITIONS (1/2)

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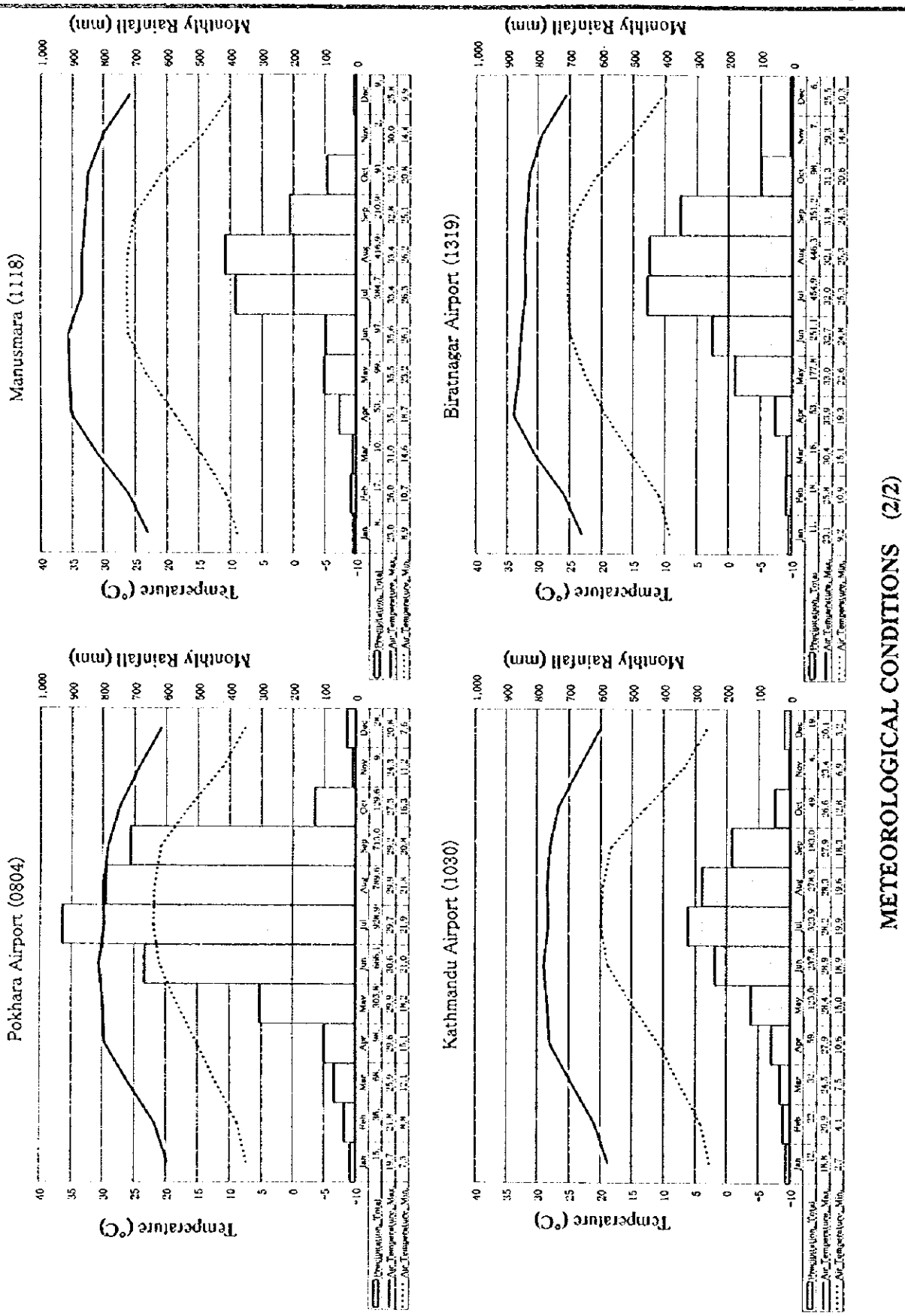
JAPAN INTERNATIONAL COOPERATION AGENCY



METEOROLOGICAL CONDITIONS (2/2)

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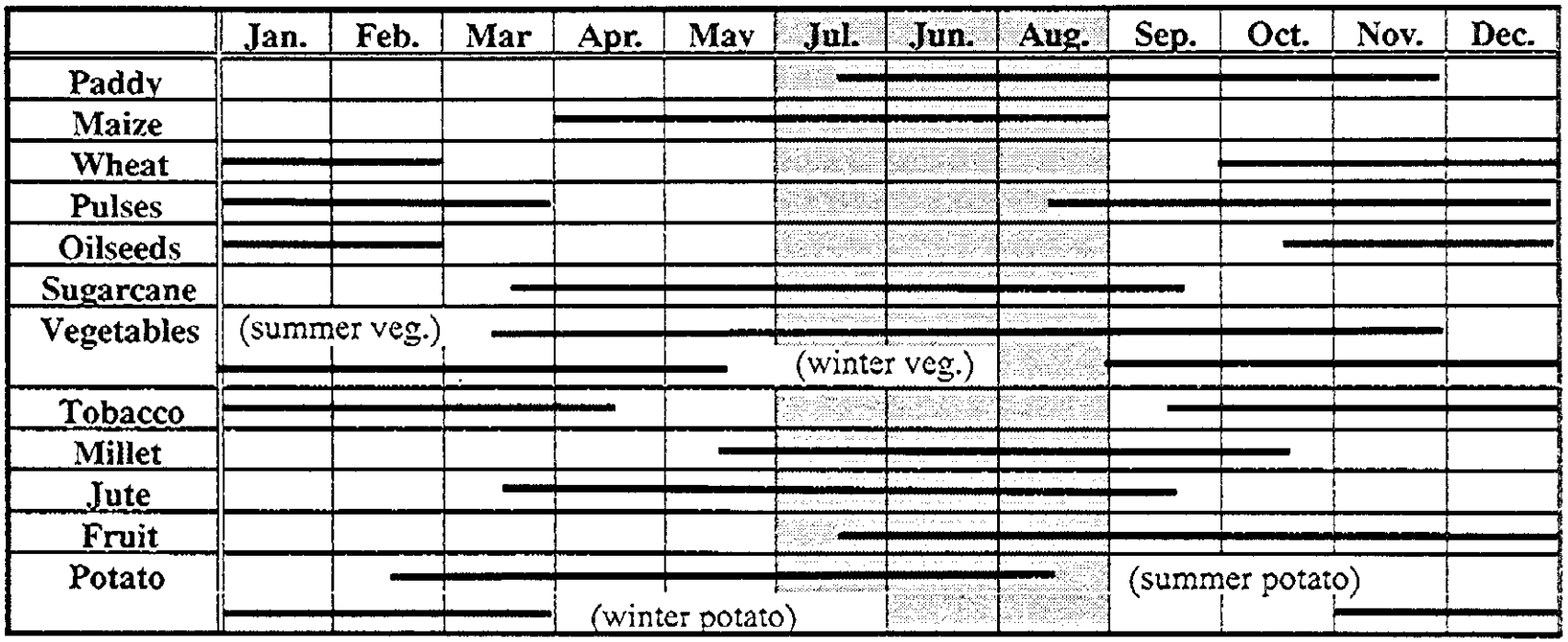
CROPPING PATTERNS IN 10 TARGET DISTRICTS



Source: interviews in 10 districts by JICA Survey Team, January 1997

Fig. 2.8

MAJOR SOCIO-ECONOMIC FACTORS TO ACCELERATE FLOODS

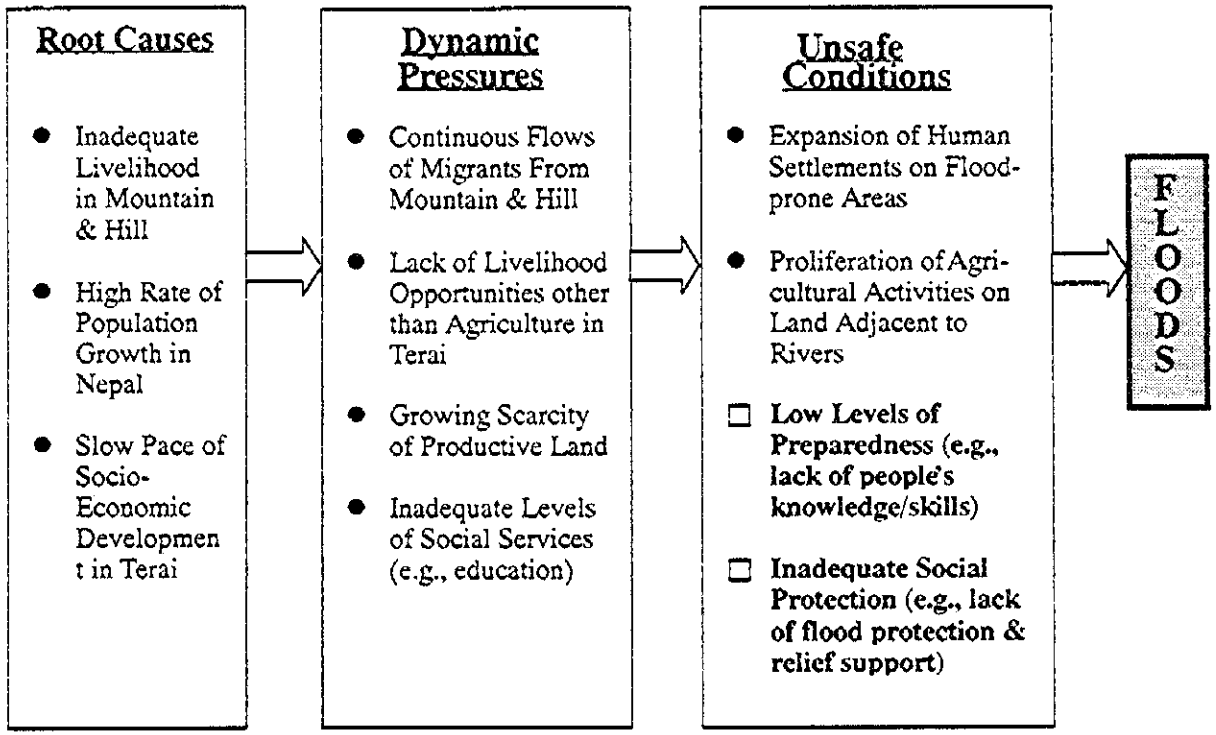


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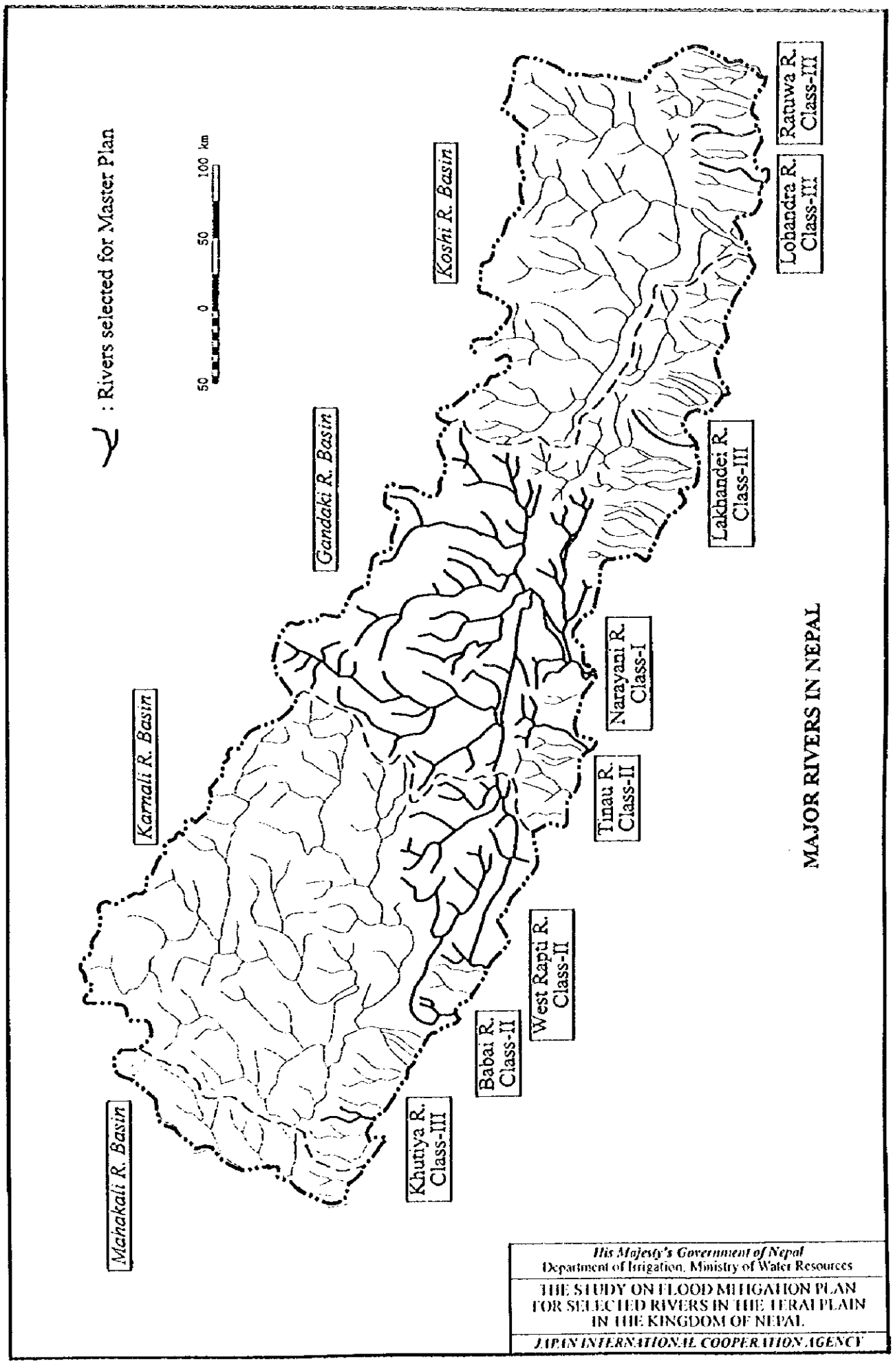
Fig. 2.10


: Rivers selected for Master Plan
50 0 50 100 km
Mahakali R. Basin
Karnali R. Basin
Gandaki R. Basin
Koshi R. Basin
Khutiya R. Class-III
Babai R. Class-II
West Rapti R. Class-II
Tinau R. Class-II
Narayani R. Class-I
Lakhandei R. Class-III
Lohandra R. Class-III
Ratuwa R. Class-III
MAJOR RIVERS IN NEPAL
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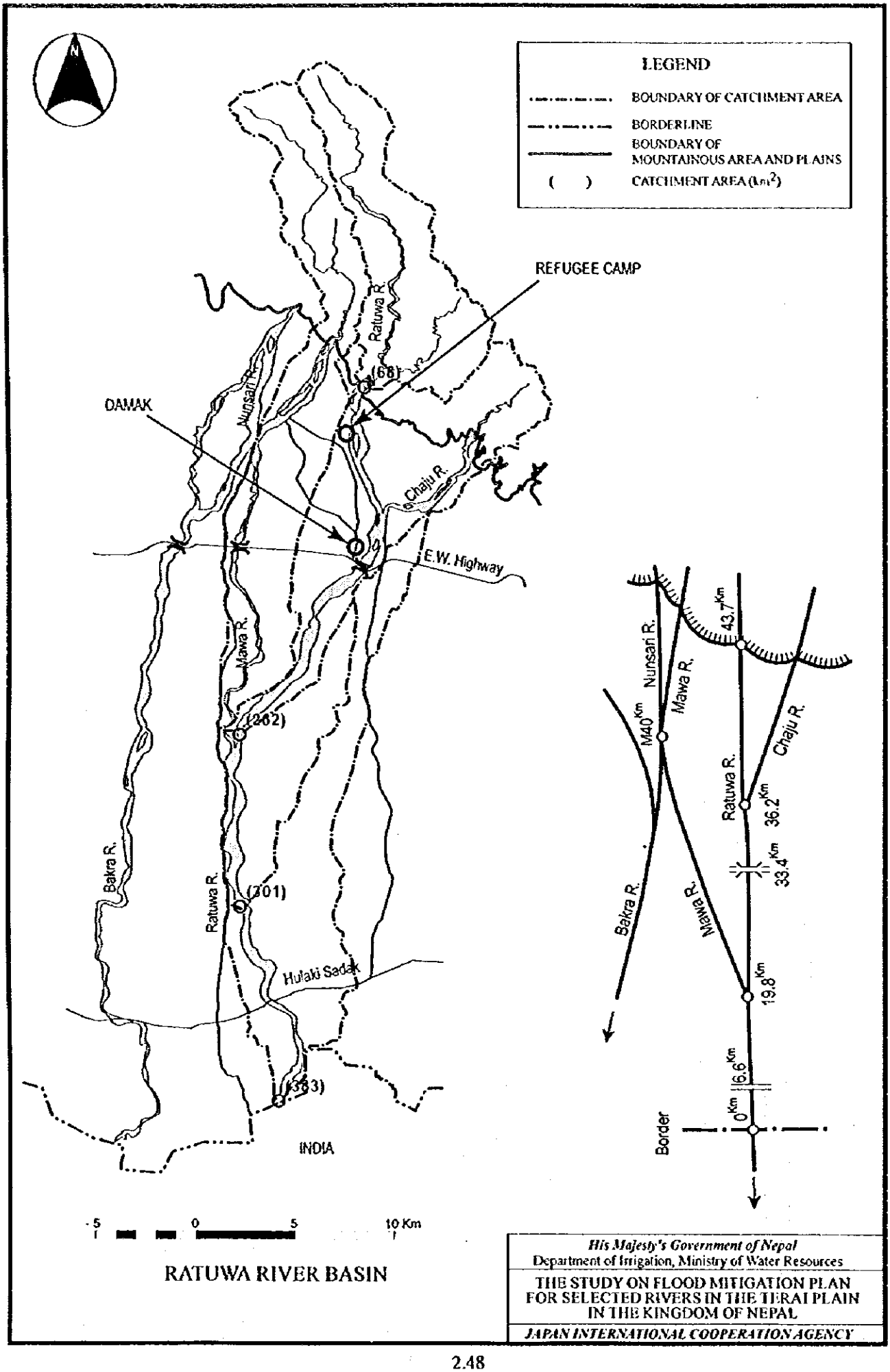
JAPAN INTERNATIONAL COOPERATION AGENCY



RATUWA RIVER BASIN

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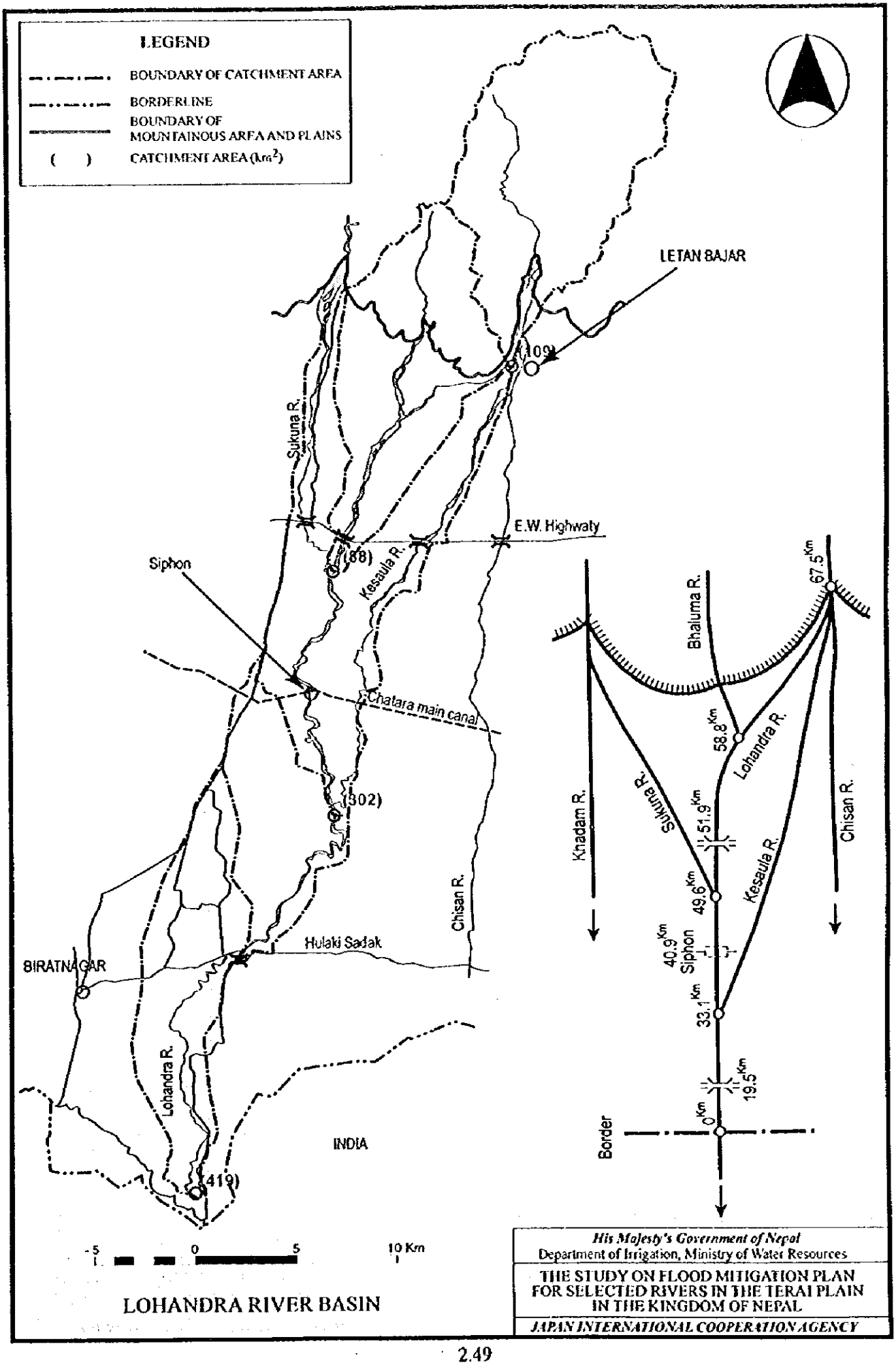
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY


LEGEND
BOUNDARY OF CATCHMENT AREA
BORDER LINE
BOUNDARY OF MOUNTAINOUS AREA AND PLAINS
( ) CATCHMENT AREA (km²)
LETAN BAJAR
(109)
Sukuna R.
E.W. Highwaty
(88)
Kesaula R.
Siphon
Chatara main canal
(302)
Chisan R.
Hulaki Sadak
BIRATNAGAR
Lohandra R.
INDIA
(419)
Bhaluma R.
67.5Km
58.8Km
Lohandra R.
Khadam R.
Sukuna R.
51.9Km
Chisan R.
49.6Km
Kesaula R.
40.9Km
Siphon
33.1Km
19.5Km
0Km
Border
5 0 5 10 Km
LOHANDRA RIVER BASIN
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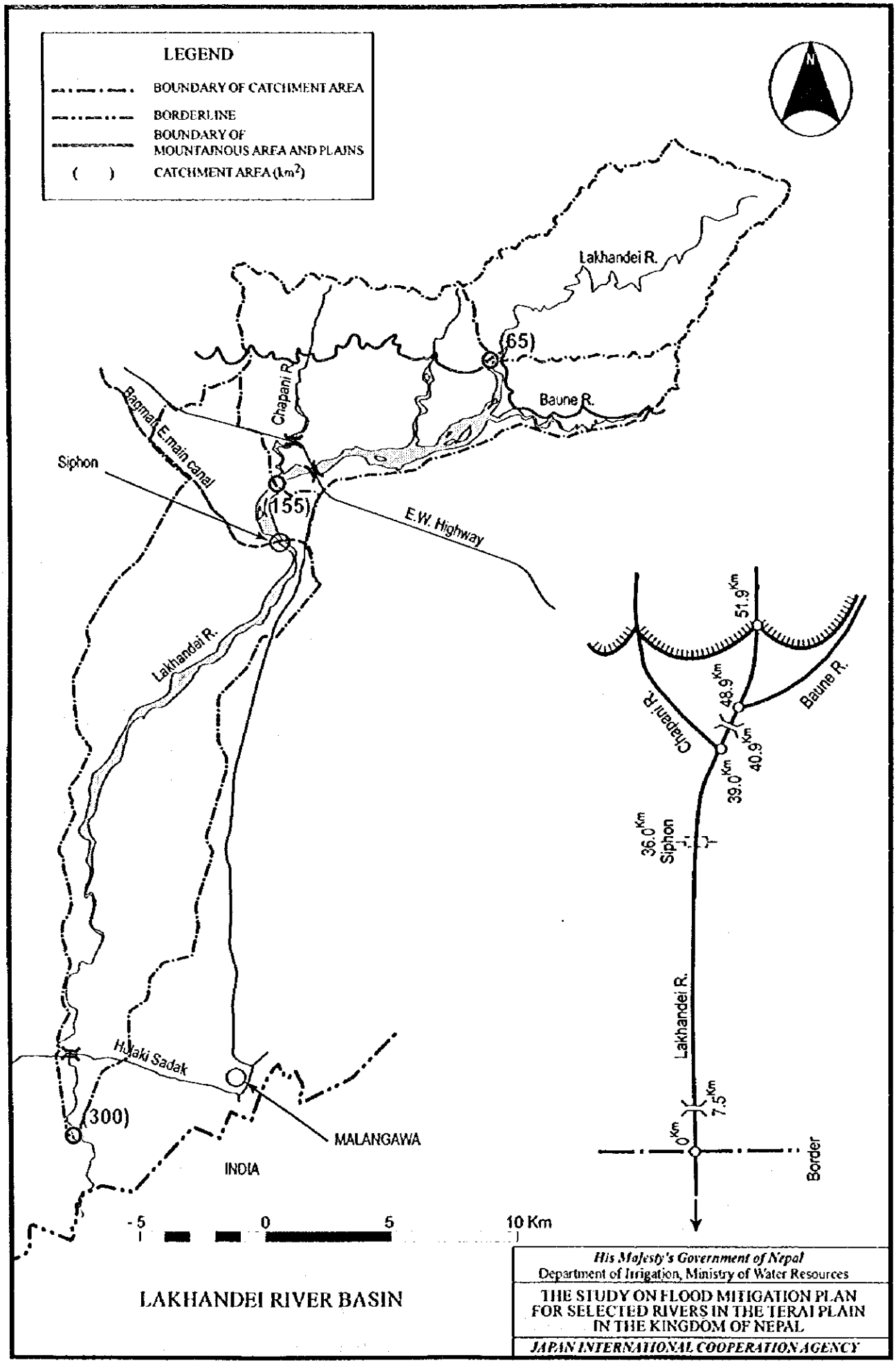
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY



LAKHANDEI RIVER BASIN

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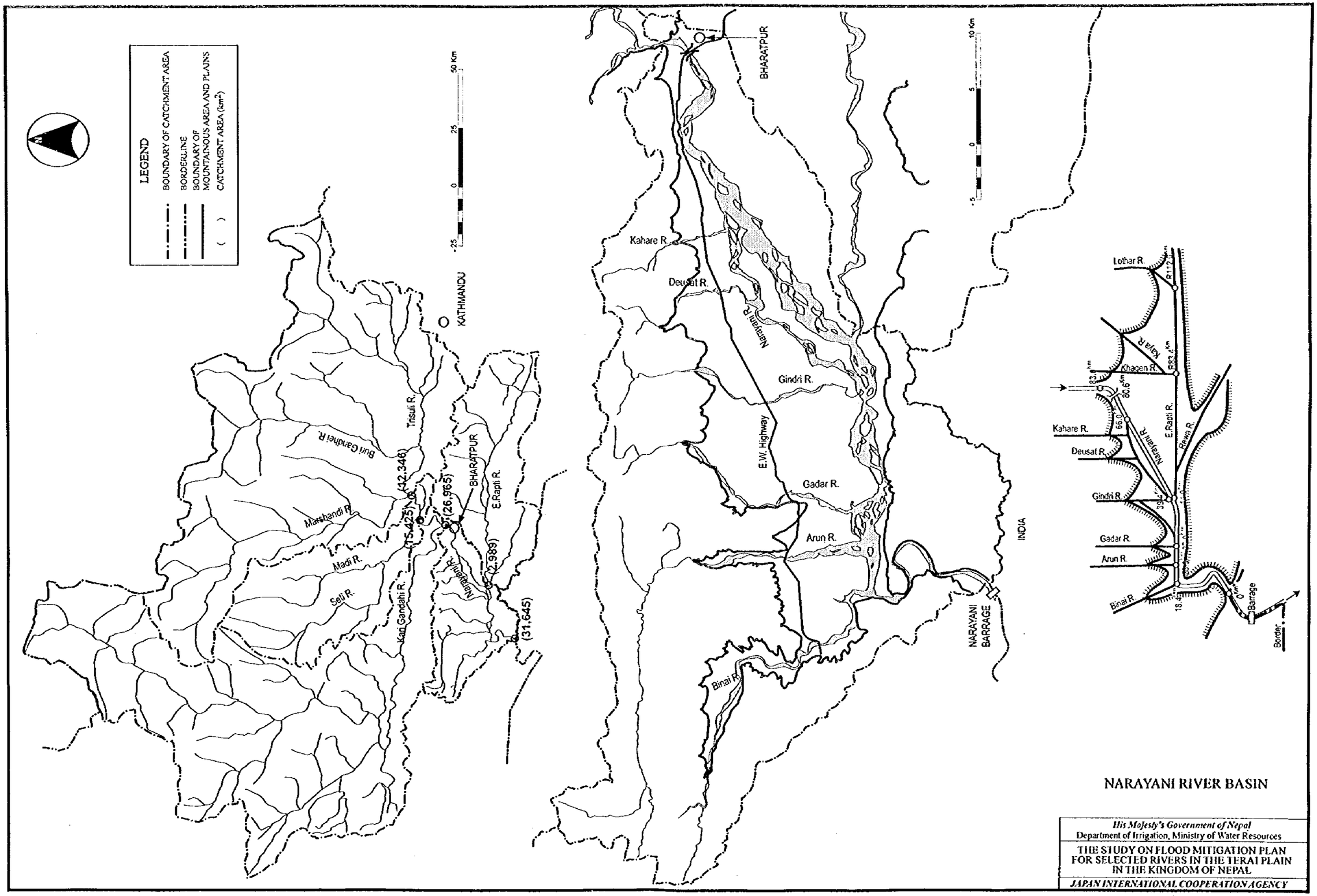
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY


LEGEND
BOUNDARY OF CATCHMENT AREA
BORDERLINE
BOUNDARY OF MOUNTAINOUS AREA AND PLAINS
( ) CATCHMENT AREA (km²)
50 Km
25
0
-25
10 Km
5
0
-5
KATHMANDU
BHARATPUR
Kahare R.
Deusat R.
Narayani R.
Gindri R.
E.W. Highway
Gadar R.
Arun R.
Binai R.
NARAYANI BARRAGE
INDIA
Bhot Gandaki R.
Trisuli R.
Marshandi R.
Madi R.
Seti R.
Kali Gandaki R.
E.Rapti R.
(42,346)
(15,425)
(26,965)
(2,989)
(31,645)
Lothar R.
Kayar R.
Khageri R.
Rapti R.
Rewa R.
E.Rapti R.
Narayani R.
Gadar R.
Arun R.
Binai R.
Barrage
Border
NARAYANI RIVER BASIN
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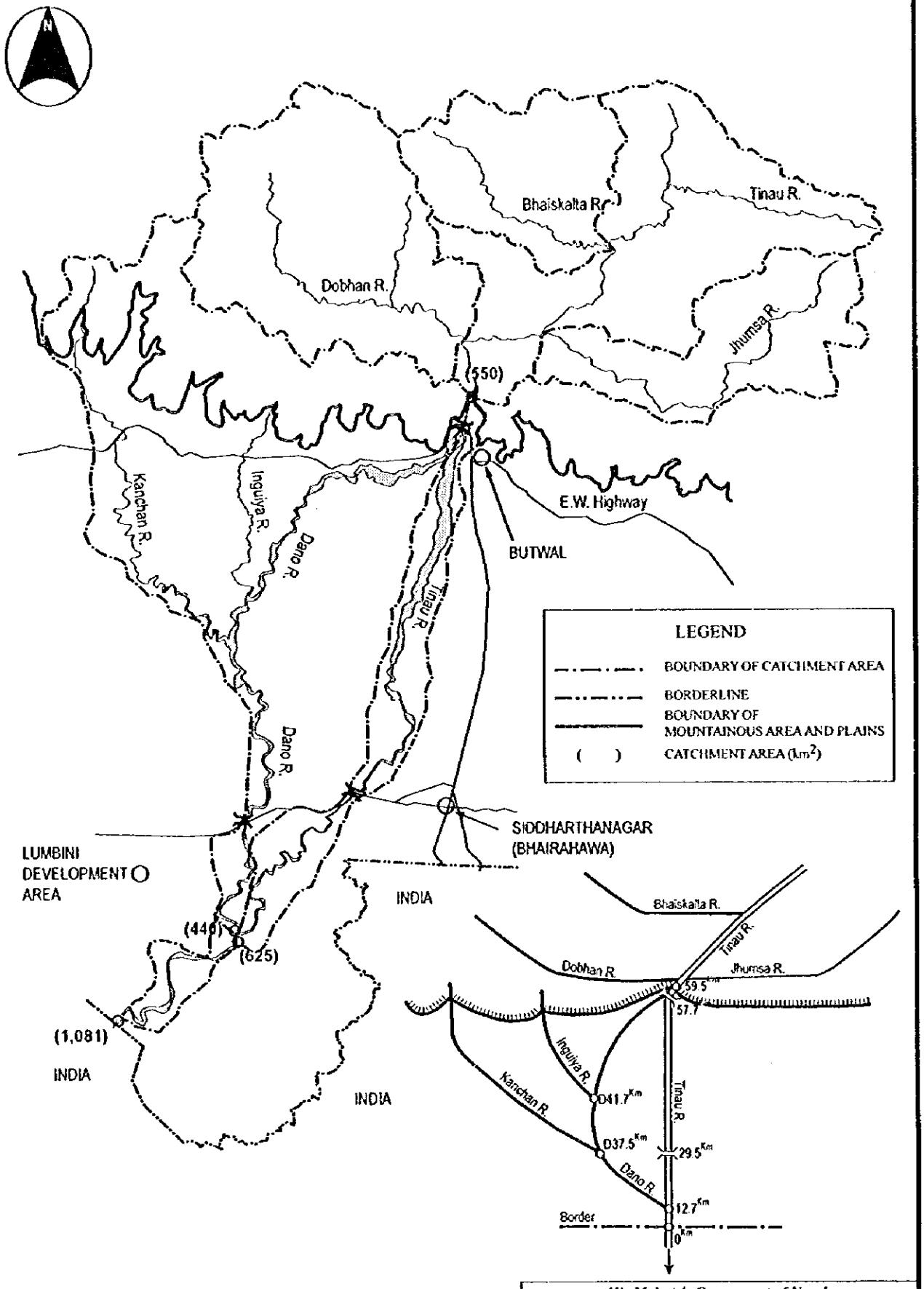
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY



TINAU RIVER BASIN

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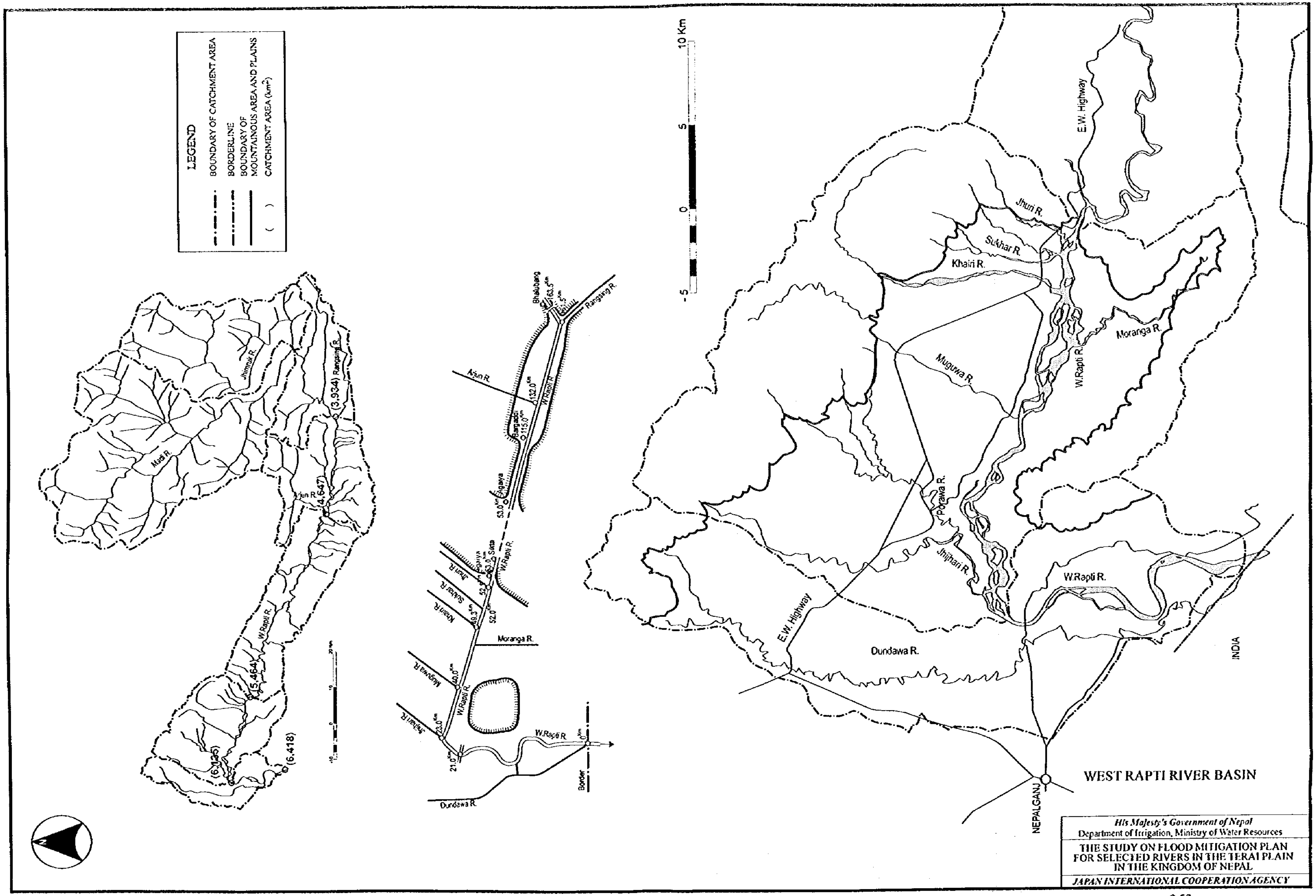
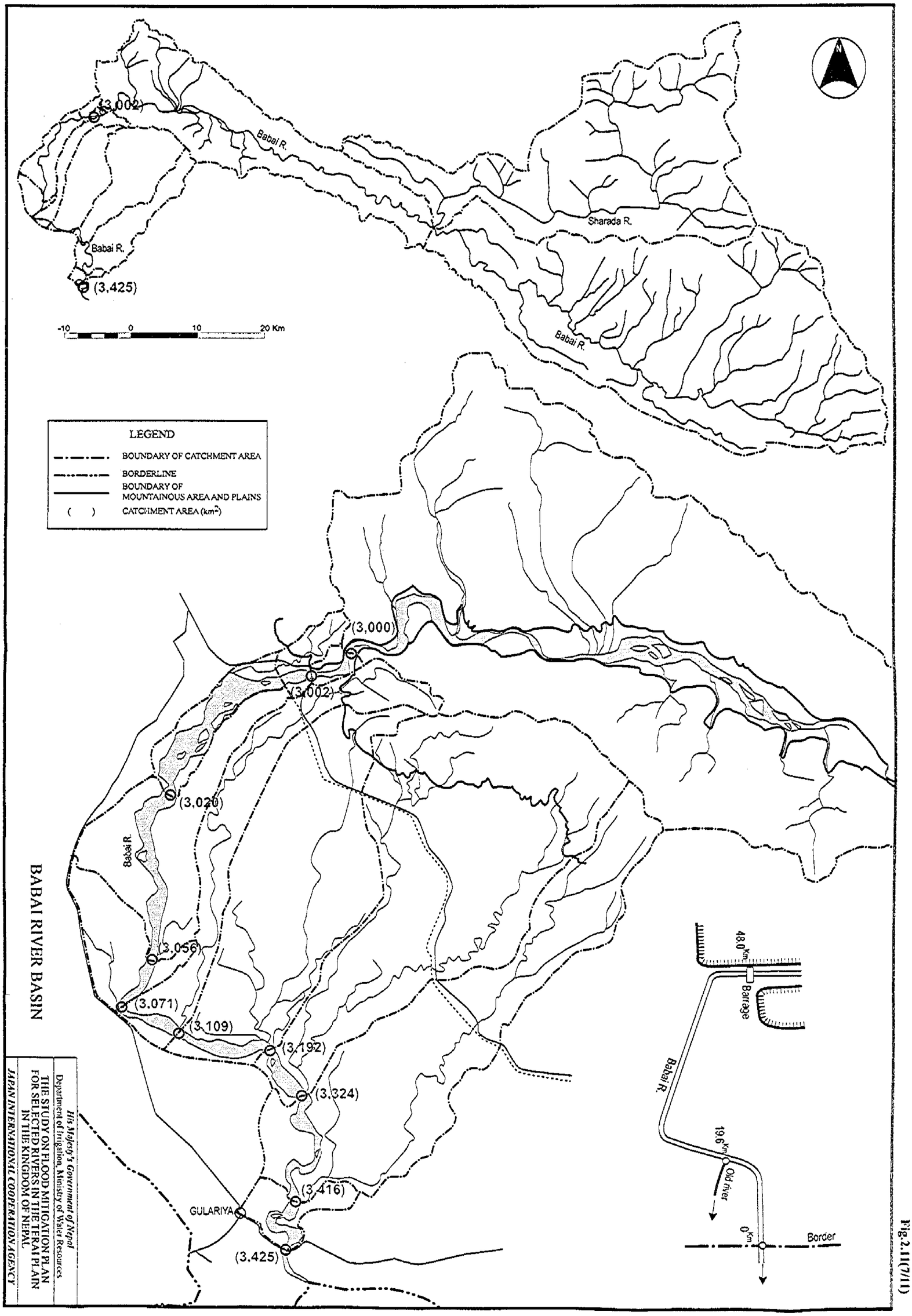
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

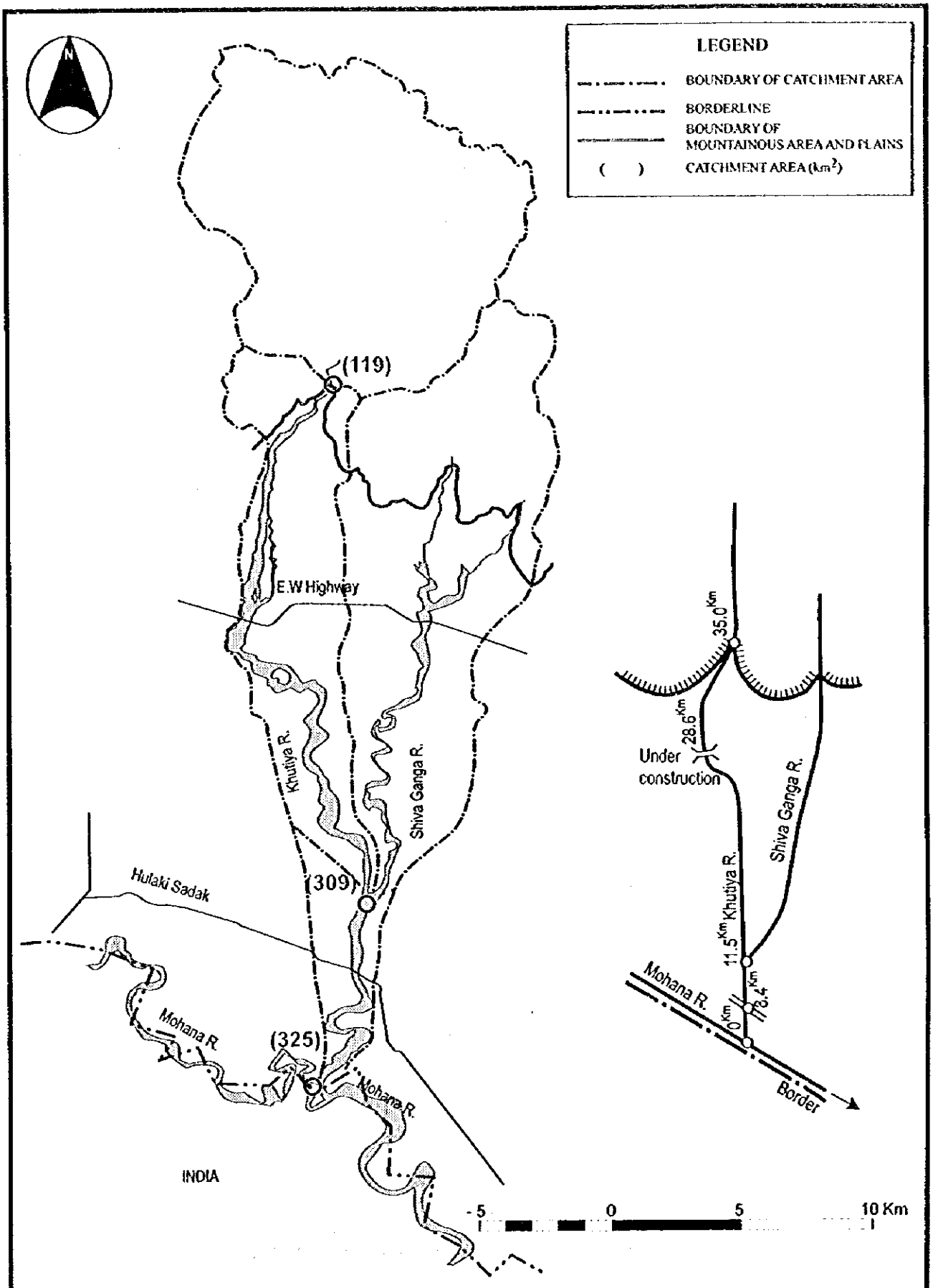

LEGEND
BOUNDARY OF CATCHMENT AREA
BORDERLINE
BOUNDARY OF MOUNTAINOUS AREA AND PLAINS
CATCHMENT AREA (km²)
10 Km
5
0
-5
Jhimruk R.
Rangsing R.
(3,934)
Nadi R.
Arjun R.
(4,647)
W.Rapti R.
(5,464)
(6,125)
(6,418)
Bhalubang
163.5
Rangsing R.
Arjun R.
132.0
W.Rapti R.
Bagasoti
115.0
Bagaya
53.0
Sikta
W.Rapti R.
Jhuri R.
Sukhar R.
Khairi R.
52.0
Moranga R.
Muguwa R.
W.Rapti R.
Jhijhari R.
23.0
21.0
W.Rapti R.
Border
Dundawa R.
E.W. Highway
Jhuri R.
Sukhar R.
Khairi R.
Moranga R.
Muguwa R.
W.Rapti R.
Parawa R.
Jhijhari R.
W.Rapti R.
E.W. Highway
Dundawa R.
INDIA
NEPALGANJ
WEST RAPTI RIVER BASIN
His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY



BABAI RIVER BASIN

His Majesty's Government of Nepal	
Department of Irrigation, Ministry of Water Resources	
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL	
JAPAN INTERNATIONAL COOPERATION AGENCY	

Fig.2.11(7/11)



KHUTIYA RIVER BASIN

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY