社会開発調査部報告書

No. 52

HIS MAJESTY'S GOVERNMENT OF NEPAL
MINISTRY OF WATER RESOURCES
DEPARTMENT OF HYDROLOGY AND METEOROLOGY

THE STUDY ON NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT PROJECT

FINAL REPORT

SUMMARY

August 1993

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO, JAPAN

HIS MAJESTY'S GOVERNMENT OF NEPAL
MINISTRY OF WATER RESOURCES
DEPARTMENT OF HYDROLOGY AND METEOROLOGY

THE STUDY ON NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT PROJECT

FINAL REPORT

SUMMARY

August 1993

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO, JAPAN

LIST OF REPORTS

SUMMARY

MAIN REPORT

ANNEXES

MANUALS

DATA BOOK

The cost estimate was based on February 1993 price level and expressed in NRs. according to the exchange rate of US$1.00 = Nepali Rupees 46.4315 = Japanese Yen 121.05 as of February 15, 1993.

PREFACE

In response to a request from the Government of the Kingdom of Nepal, the Government of Japan decided to conduct a study on Nationwide Hydro-meteorological Data Management Project in the Kingdom of Nepal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Nepal a study team headed by Mr. Masaru Koshiba, Nippon Koei Co., Ltd., five times between May 1991 and June 1993.

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

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Nepal for their close cooperation extended to the team.

August 1993

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

August 1993

Mr. Kensuke Yanagiya
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

Letter of Transmittal

We are pleased to submit herewith to you the Final Report of "the Study on Nationwide Hydro-meteorological Data Management Project" in Nepal. This Report has been furnished for His Majesty's Government of Nepal as a guideline to lead the existing hydro-meteorological observation and data management systems to more satisfactory and competent ones, based on the study which had been conducted during a period from March 1991 to July 1993 in accordance with the agreement of both the Governments of Japan and Nepal.

The Report comprises five (5) volumes consisting of the Summary, Main Report, Annexes, Manuals and Data Book. Main outputs presented in the Report are the Long Term Programme and the Immediate Programme. The former Programme aims to establish firm and reliable systems of hydro-meteorological observation and those data management. A target year of this Programme is set at 2005. The latter Programme proposes to improve on quality and accuracy of those data by strengthening the systems urgently within the target year of 1995. The Report mentions also design, construction and operation of the Model System established during the study period.

Improvement of the present observation facilities and data management systems is inevitably required to obtain the reliable data for planning and designing of development schemes such as hydropower, water supply, irrigation, flood control, watershed management and so forth, economically and viably. Therefore, an immediate implementation of both the Programmes shall be eagerly recommended.

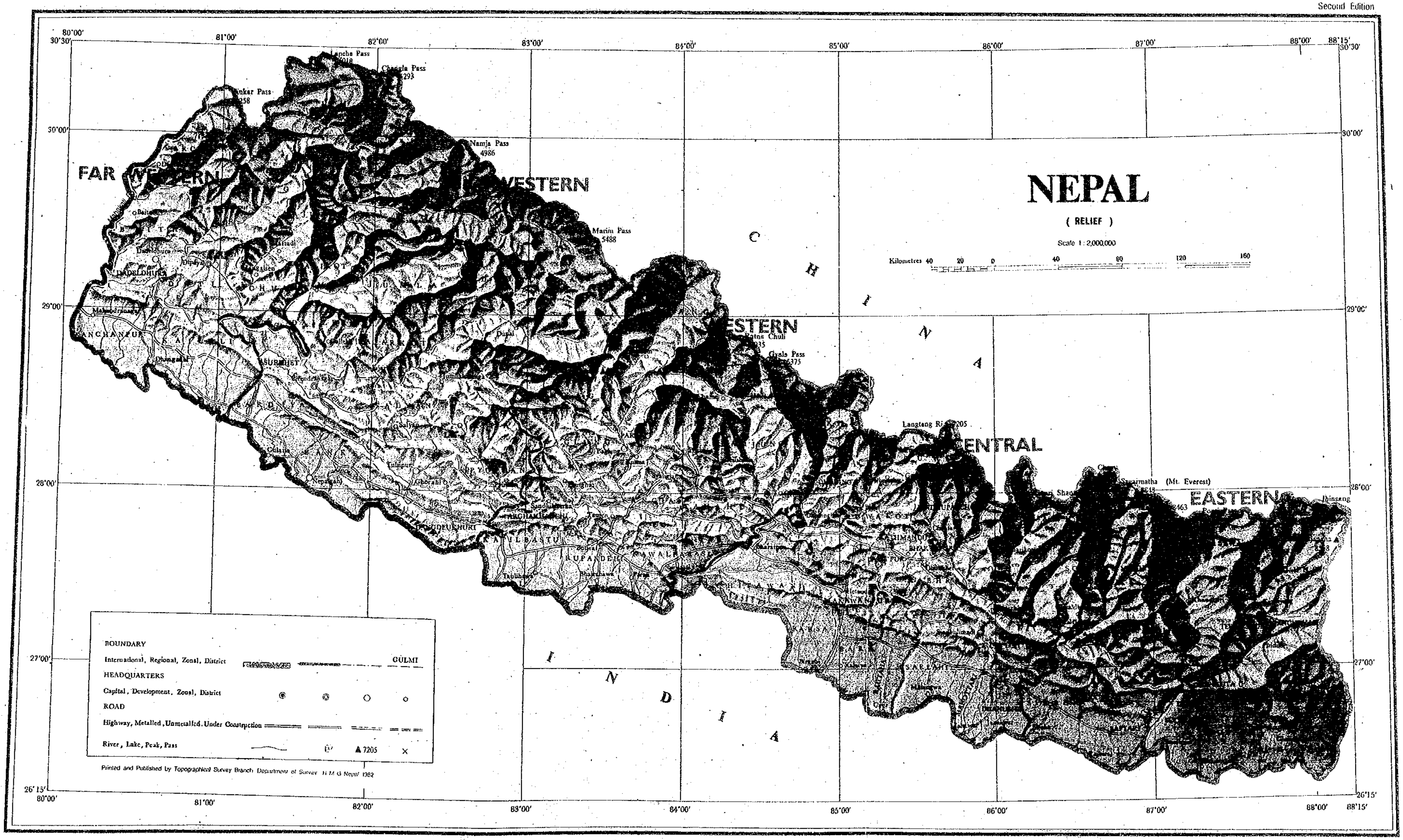
All members of the Study Team wish to express their grateful acknowledgement to the personnel from your Agency and Ministries of Foreign Affairs and Construction as well as the officials and individuals from Nepal for their kind assistance extended so far to the Study Team. Sincerely the Study Team hopes that the outputs presented in the Report will render the future improvement of the existing observation facilities and data management systems.

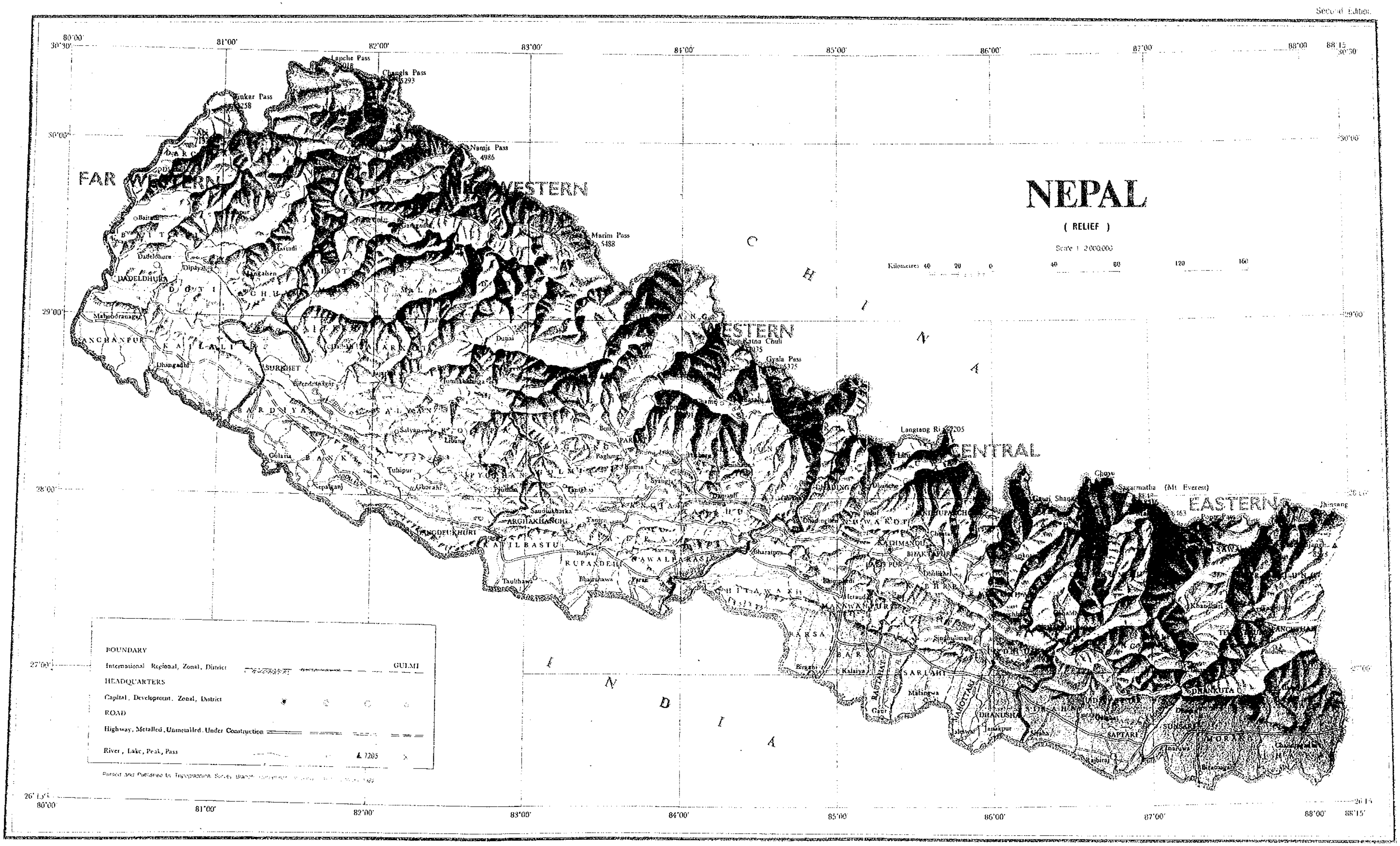
Yours faithfully,

M. Koshiba

Masaru Koshiba
Team Leader
Nationwide Hydro-meteorological
Data Management Project

Second Edition




Second Edition
NEPAL
(RELIEF)
Scale 1 : 2,000,000
Kilometres 40 20 0 40 80 120 160
FAR WESTERN
MID WESTERN
WESTERN
CENTRAL
EASTERN
CHINA
INDIA
Sagarmatha (Mt Everest)
KATHMANDU
Langtang Ri 7205
Namja Pass 4986
Marim Pass 5488
BOUNDARY
International, Regional, Zonal, District
GULMI
HEADQUARTERS
Capital, Development, Zonal, District
ROAD
Highway, Metalled, Unmetalled, Under Construction
River, Lake, Peak, Pass
7205

NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT PROJECT

OUTLINE OF STUDY

1. Background

The water resources in Nepal are one of the most important natural resources for the economic development. On the contrary, Nepal suffers from flood damage in the rainy season every year. In view of such circumstances, His Majesty's Government of Nepal (HMG/N) had put stress on realization of river control and water resources development in previous national five-year plans. For the study of the control and development, improvement of existing hydro-meteorological observation and data management systems became the most urgent requirement. The Department of Hydrology and Meteorology was established in 1987. Then, the HMG/N requested an assistance for the improvement to the Government of Japan and this Study began in March 1991.

2. Objectives of the Study

The objectives of the Study are 1) to formulate improvement plans for nationwide hydro-meteorological data management system, and 2) to undertake the transfer of technology to the HMG/N counterparts.

3. The Study

Investigations and studies were carried out from March 1991 to July 1993. The Model System was established and the Long Term and Immediate Programmes were formulated in this period.

4. Model System

Purpose	:	strengthening the existing system and using the result for formulating the Programmes
Model Basin	:	Kali Gandaki river basin (7,110 km^2) and Jamuni river basin (110 km^2)
Model Station	:	14 raingauge stations equipped with both ordinary and recording raingauges, and 4 water level gauge stations with both staff gauges and recording gauges and cableways
Computer	:	7 sets of computers with printers and accessories
Installation	:	May 1991 to March 1992 including design work
Civil Cost	:	NRs. 8,873 thousand (= Yen 27,825 thousand)

5. Long Term Programme (target year 2005)

Purpose	:	establishing the firm hydro-meteorological observation and data management system to obtain nationwide, long term and reliable data for hydrological analysis and water resources development planning
Observation Item:		precipitation,water level, discharge, sediment and water quality
18 Systems	:	precipitation observation system (total 470 stations including 394 ordinary and 46 recording gauges to be rehabilitated or newly installed and existing ones without repair)

water level observation system (total 110 stations including 10 basic stations, 38 primary stations and 62 secondary stations to be improved)
discharge measurement system (100 cableways to be repaired or newly installed and 40 new current meters)
sediment sampling system (20 stations with new samplers)
water quality sampling system (introduction of system at 11 stations)
sediment analysis system (turbidity meters, electric ovens and balances, and sieves to be introduced or repaired)
water quality analysis system (test kits and laboratory with equipment to be introduced)
establishment system, and inspection and maintenance system (introduction of systems, workshop and current meter calibration facility to be introduced)
data collection system, data processing system, data storing system, and data dissemination system (introduction of systems with 19 new computers)
data quality research system (introduction of system)
training system (training center and foreign experts to be introduced)
progress control system, quality control system, and evaluation system (introduction of systems)

Organization : a central office, 4 basin offices and 10 branch offices with 138 technical staff

Cost : NRs. 878 million including foreign currency of NRs. 633 million and local currency of NRs. 245 million

IRR : 30.2 % as a result of case study

6. Immediate Programme (target year 1995)

Purpose : improving quality of the hydro-meteorological data urgently by strengthening the existing system

Observation Item: precipitation, water level, discharge and sediment

16 Systems :
precipitation observation system (rehabilitation of 82 ordinary and 14 recording gauges)
water level observation system (10 basic stations to be strengthened)
discharge measurement system (21 cableways to be improved and 25 new current meters)
sediment sampling system (establishment of system with 20 stations)
sediment analysis system (turbidity meters, electric ovens and balances to be repaired or newly introduced)
establishment system, and inspection and maintenance system (same as the Long Term Programme)
data collection system, data processing system, data storing system, and data dissemination system (same as the Long Term Programme with 14 computers to be introduced)
data quality research system, training system, progress control system, quality control system and evaluation system (same as the Long Term Programme)

Organization : same organization as the Long Term Programme with 129 technical staff

Cost : NRs. 366 million including foreign currency of NRs. 275 million and local currency of NRs. 91 million

NATIONWIDE HYDRO-METEOROLOGICAL
DATA MANAGEMENT PROJECT

FINAL REPORT
SUMMARY

CONTENTS

OUTLINE OF STUDY Page

Page

Page

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 Background

Nepal holds an area of 147,181 km^2. The water resources of rivers are one of the most important natural resources for the economic development of the country. On the contrary, Nepal suffers from heavy flood damage in the rainy season every year. In view of such circumstances, His Majesty's Government of Nepal (HMG/N) had put stress on realization of river control and water resources development in preceded five-year plans of national development. Rectification and intensification of existing hydro-meteorological observation networks and its data management accordingly became the most urgent requirement to the HMG/N for the effective water resources development and control. Measures for the rectifications and intensifications have been taken by the HMG/N with the cooperation of the UNDP. An establishment of the Department of Hydrology and Meteorology (DHM) was realized in 1987. An assistance to further improvement and reinforcement of the said observation and data management system was requested to the Government of Japan by the HMG/N. In response to this request, this Study began in March 1991.

1.2 Objectives of the Study

The objectives of the Study are as follows:

1) To formulate improvement and extension plans for nationwide hydro-meteorological data management system comprising:
   a) hydro-meteorological observation network system and
   b) data management system,
2) To undertake the transfer of technology to the HMG/N personnel and counterparts by the experts of the JICA Study Team in the course of the Study.

1.3 The Study

Investigations and studies were carried out during the period from March 1991 to July 1993. The Model System was then established and the Long Term and Immediate Programmes were proposed for improvement of the existing hydro-meteorological data management system. Transfer of technology has been conducted by the Study Team through on the job training and some training programmes during the execution of investigations and studies in Nepal. The Final Report was prepared compiling all the investigation and study results and submitted in August 1993.

2. PRESENT SOCIO-ECONOMIC AND NATURAL RESOURCES CONDITIONS

2.1 Socio-Economy

Nepal is a traditional agricultural country having a population of about 18.5 million in 1991 with annual growth rate of 2.08% between 1981 and 1991. Approximately 90% of the economically active population engages in the agricultural and agro-industrial sectors which account for more than 50% of the Gross Domestic Product (GDP). In the fiscal year 1991/92, the GDP amounted to nearly US$ 3,000 millions, whereas the per capita GDP was only US$ 160. Budget expenditures of the Government amounted to NRs. 26,641 millions in the fiscal year 1991/92 with average annual growth rate of 18.27% for the period 1986/87-1991/92. The country is divided into five development regions; Eastern, Central, Western, Mid-Western and Far-Western Development Regions. In Nepal, the Seventh National Development Plan (1985/86-1989/90) was finished in 1990 and the Eighth Plan (1992/93-1996/97) was started successively.

2.2 Topography and Geology

Nepal is a mountainous country stretched over 147,181 km^2. The country lies between latitudes 26°22' and 30°27' north and longitudes 80°04' and 88°12' east with the length of about 885 km on an average from east to west and width of 130 to 260 km from south to north. Nepal is usually divided into five topographical regions from south to north, which are Terai, Siwalik Ranges, Middle Mountains, High Mountains and High Himalaya. The Terai zone is nearly plain area with alluvial deposited dip towards north. Siwaliks zone is relatively low hill and of youngest rock, located at southern part of the Middle Mountains. In case of the Middle Mountains, the bed rocks are metamorphosed sedimentary strata of greater age, dipping towards north. The High Mountains zone rocks are gneiss and quartzite. On the High Himalaya zones, gneisses display a normal, upward decrease in metamorphism and grade into a fossiliferous sedimentary sequence which ranges from Cambro-ordovician to Eocene.

2.3 Hydro-Meteorology

In Nepal, there are five major climatological zones: subtropical, warm temperature, cool temperature, alpine, and arctic. The annual mean precipitation is around 1,530 mm in the whole of Nepal. More than 75% of rainfall occurs during the monsoon period from June to September. It is of longer duration in eastern Nepal than in the western area. Heaviest rainfall is recorded along the southern margin of the Great Himalaya Range reaching

5,000 mm yearly and along the southern foot of the Siwaliks or the Mahabharat Ranges. The general precipitation condition is given in Fig. 1. Air temperature rises usually during the premonsoon period in February to May. It decreases during postmonsoon period in October to January.

The concentrated runoff within three months of the year, viz., July, August and September, is typical of the rivers in Nepal. The discharge during these three months accounts for about 65% of the total annual runoff, while for the rivers with smaller drainage area the percentage rises to around 75%. The annual average runoffs are around 1,400, 1,590, and 1,500 cu.m/s in the Karnali, Gandaki, and Koshi river respectively. The general river runoff condition is shown in Fig 2. The map of rivers and river basins in Nepal is shown in Fig.3 and the drainage areas are given in Table 1.

2.4 Communication and Transportation

Although railways and ropeways are now being operated within some limited areas, the major transport depends on roads and a part of the road transport is supplemented by air transport. The major communication media of Nepal are telecommunication and postal services. But the number of these telecommunication and post facilities is insufficient to serve a population amounting to about 18.5 million.

3. PRESENT CONDITION OF HYDRO-METEOROLOGICAL OBSERVATION AND DATA MANAGEMENT SYSTEMS

3.1 Role of DHM

In 1921, the first rainfall station was established at the Indian Embassy in Kathmandu. Following this station, four climatological stations and about a hundred precipitation stations were established and operated in Nepal by the India Meteorological Department. The systematic collection of hydrological data in the Karnali basin was started in 1961 by the UN Special Fund for the feasibility study on power project. After that, many projects and international assistances on hydrology and meteorology were implemented in Nepal. The governmental agency in charge of hydrology and meteorology was reorganized several times in the course of the above implementations. In 1987, the Department of Irrigation, Hydrology and Meteorology was reorganized into the Department of Irrigation (DOI) and the Department of Hydrology and Meteorology (DHM).

The DHM is one of the Departments under the Ministry of Water Resources. The DHM is responsible to fulfill the role of observation, management, analysis, forecast and

dissemination of hydrological and meteorological data and information. The DHM consists of three (3) Divisions, five (5) Regional Offices and two (2) Sections as shown in Fig.4. These Divisions are Hydrology, Meteorology and Weather Forecasting, and Climatology Divisions. Two Sections are Administration and Accounts, and Other Technical Services. Regional Offices are Eastern, Central, Western, Mid Western and Far Western Regional Offices. In the Central Office, 122 technical staffs are engaged in the technical Divisions/Sections. Technical staffs in the Regional Offices are 102 in number. Among them 32 staffs belong to 13 Synoptic stations. Total budget expenditure of the DHM in the fiscal year of 1992/1993 is 26,984 thousand NRs. including regular budget of 6,304 thousand and development budget of 20,680 thousand NRs. Some discussions on restructuring of the DHM organization were done and new organization has been effective from mid-July 1993.

3.2 Observation

At present, 252 meteorological stations are operational in the whole Nepal except for the Model System. The density of distribution is around 580 km^2/gauge on an average which seems to be insufficient judging from assessment of rainfall distribution patterns and a norm for minimum network recommended by the WMO. Moreover the network is biased. The locations are shown in Fig.5. No systematic snow measurement is performed at present except for six stations under the Snow and Glacier Hydrology Project. Among 252 stations, 14 stations are equipped with rain recorder. Weighing-type and float with syphon-type ones are used with chart type recorder. Part-time observers appointed by the DHM take observation except for the Aeronautical and Synoptic stations.

A total of 136 water level gauging stations are in operation as of August 1991. The locations are shown in Fig.6. The average gauge distribution density of around 1,100km^2/gauge is nearly sufficient comparing with the WMO norm. However biased gauge distribution should be corrected. The automatic recorders are installed in 34 stations. Suspended sediment sampling is carried out in 18 stations. There is no nationwide observation system of water quality. Float-type gauge installed in a stilling well is in common use in Nepal. However, some gauge wells are suffering from sedimentation and scouring of the riverbed. Pressure-type gauges are also operated. Eighty two (82) observation stations are equipped with cableway facilities for discharge measurement. Almost all of discharge measurements are carried out by current-metering method though the number of measurements is 3 to 4 only in a year. Price type current meter is mainly used. There are some suspended sediment sampling apparatus. However, a part of them are damaged and useless. In hydrometric stations, gauge readers, sediment sample collectors, winch operators, and bottle runners carrying sediment sampling bottles to the

laboratory are employed by the DHM as part-time observers/workers. Field technicians of the Regional Offices are in charge of discharge measurement, levelling and river cross section survey, field inspection and minor maintenance activities. In all the sediment stations no velocity measuring and grain size analysis is done. No suitable manual is used and technical level of observers is not sufficient.

3.3 Sediment and Water Quality Analysis

One sediment laboratory is operated in the Central Office in Kathmandu and four sediment laboratories are distributed in Far-Western (Chisapani), Mid Western (Dang), Western (Pokhara) and Eastern Regional Office (Dharan). In August 1991, two laboratories in Dang and Dharan, were not operational due to malfunction of equipments. Analysis staff does not have enough knowledge. And, there is not analysis manual. No gradation analysis of suspended sediment load and no analysis of bed material load is made. There is no systematic water quality analysis.

3.4 Establishment, Inspection and Maintenance of Facility

Field inspection of Precipitation stations is carried out once or twice a year by technicians of the Regional Office without overall schedule. There is no inspection manual. Inspection at the Synoptic stations is carried out by mechanics of meteorological instrument workshop in the Central Office. Field inspection of hydrometric stations is carried out in an average two or three times a year. Inspection form is provided but there is no inspection and maintenance manual. Technical level of staff on inspection and maintenance is however not sufficient due to lack of proper training. Station and instrument inventories are incomplete and not updated. A meteorological and a hydrological instrument workshops were provided in the Central Office. Operation condition of both workshops is not good due to lack of tools and spare parts and staff training. There is no calibration facility of the current meter and most current meters have been used without calibration.

3.5 Data Processing and Management

Soon after the monthly recording forms are filled with observed data at the station of ordinary raingauge and staff gauge, they must be sent to the Regional Offices by mail to reach within one month after finishing observation. However,around 50% of the data reached the Regional Offices within one month. The reasons of the above delay are delay of data sending by observers due to severe and long accessibility to post offices, irregular data sending by observers' convenience at an interval of more than two months or insufficient management of the Regional Office for data collection activities.

The collected data were preliminarily processed at the Regional Offices by manpower without using computer till 1991. In 1992, this Project introduced laptop type computers to all the Regional Offices and some processing works are being done by using these computers. The processed data are printed out and sent to the Central Office. The present meteorological data processing is in good progress. However, hydrological data processing shows some facts to be improved. Especially discharge rating curves were not developed smoothly.This may be caused by insufficient number of discharge measurements, lack of experienced hydrologists to develop it, and lack of monitoring systems to expedite the development. Data checking is not sufficiently done. And there is no data processing manual except for a computer manual. A monitoring form of data processing does not function well. All the data are sent to the Central Office from the Regional Offices by the staffs. However, the registration is incomplete and sometimes delayed. The progress of the meteorological data processing is relatively good. The data are checked by using the entry programme of the existing database and by visual check of the Meteorologist. However, continuous rainfall data have remained unprocessed. The present processing work in the Central Office on mean daily water level data shows relatively good progress with approximate completion of data entry and estimate of mean value in 1991. However, calculation of mean daily discharge is not in good progress. This may result from the delay of discharge rating curve development. Overal data checking has been carried out by the Hydrologists. The DHM has two data base systems, one is a meteorological data base system and the another is a hydrological data base system. These systems consist of 6 sets of IBM computers and their accessories except for the Model System.

The original hydro-meteorological records sent from the Regional Offices are stored in the storeroom of the DHM Central Office. However the hydrological data are piled randomly, which should be improved for proper storing and future use. The processed data are stored in the present data bases. Only the Central Office disseminates hydro-meteorological data and results of analyses to the users in the form of summary report, data book, computer output, disk, report on weather forecasting and broadcasting programme.

3.6 Data Quality Improvement and Training

No continuous and systematic survey and study on observation network and data management have been conducted for the purpose of their improvement. The existing manuals or forms have seldom been modified and intensified. There is no routine dialogue with users of the hydro-meteorological data. It is necessary to perform technical training

for junior technical staff and observers. In the year of 1992, four training courses were conducted by the DHM.

3.7 Preceding and Ongoing Projects Related to DHM

UNDP funded project - Development of Operational Hydrology Services started in June 1982 and completed in 1987 with the objective to develop and strengthen the institutional capability of the HMG/N in hydrological services. The main outputs were repair of 25 hydrometric stations, preparation of station inventories, establishment of database, compilation of year book and introduction of computer equipments.

The German Development Services (GDS) has provided the DHM with assistance to improve and strengthen technical and managerial works of the Department since 1986. Their main works are guidance of hydrological observation and data processing, assistance to plan training programme, and installation of some gauges.

The Snow and Glacier Hydrology Project was initiated in 1987 with the technical assistance of the German Technical Cooperation Agency (GTZ) and continues until 1995. The objective of this pilot project is to organize a Snow and Glacier Hydrology Unit within the DHM and to establish six hydrometeorological stations in the snow and glacier regions of the Nepal Himalaya to collect data relevant to water resources planning.

The Nepal-India Flood Forecasting Project, which was initiated in 1984, aims to provide real-time hydro-meteorological data to India for flood forecasting purpose by establishing 20 water level gauging stations along with ordinary and recording raingauges and other 25 raingauging stations. Among these stations, 9 water level gauging stations with raingauges and 7 other raingauging stations are in operation at present.

In order to promote prevention/mitigation of water induced disasters, it was agreed in October 1991 between HMG/N and the Government of Japan to establish Water Induced Disaster Prevention Technical Centre (DPTC). The objective of the DPTC is to strengthen capability of the HMG/N to cope with water induced disasters through technology development, provision of training and establishment of Data Base. The DPTC is now in operation.

4. FORMATION AND CONCEPT OF THE PROJECT

4.1 Purpose of Improvement Programme

The DHM is eager to continue hydrological study to grasp in detail the nationwide hydro-meteorological characteristics by using long term, reliable and widely observed data. To cope with the predicted deficit of power and food, many water resources development projects such as hydropower and irrigation are identified to be implemented. Water induced natural disasters such as flood and soil erosion are also serious problem. Long term and reliable hydro-meteorological data are requisite for planning and design of the future water resources development projects mentioned above. The purpose of the Improvement Programme is, therefore, establishing the firm hydro-meteorological observation system and its data management system serving to observe and manage nationwide, long term and reliable data which are useful for and ensure analysis of hydrometeorological characteristics in the whole country, evaluation of national water resources, planning of the water resources development projects and management of river discharges. Observation items in the Improvement Programme are precipitation, river water level and discharge, sediment load and water quality, all of which are fundamental and essential to disclose hydrological features of the whole Nepal and to plan and design water resources development projects.

The Improvement Programme, however, does not include observation and management systems of meteorological parameters, snow and glacier, limnology and real time data. However, it is emphasized that these items should be reviewed and their improvement plans should be studied under the DHM on the earliest occasion.

Final target of the Programme on data dissemination is to compile and publish the observed high-reliability data within the next year. In order to achieve this target, Basin Office and Branch Office are introduced instead of Regional Office for proper management of data. One Basin Office will manage one main river basin. The following 18 systems are introduced in the nationwide hydro-meteorological data management system:

(1) For Observation; Precipitation Observation System, Water Level Observation System, Discharge Measurement System, Sediment Sampling System, Water Quality Sampling System,

(2) For Sediment and Water Quality Analysis; Sediment Analysis System, Water Quality Analysis System,

(3) For Establishment, Inspection and Maintenance of Facility; Establishment System, Inspection and Maintenance System,

(4) For Data Processing and Management; Data Collection System, Data Processing System, Data Storing System, Data Dissemination System,

(5) For Data Quality Improvement and Training; Data Quality Research System, Training System,

(6) For Monitoring and Evaluation of Activities; Progress Control System, Quality Control System, Evaluation System

The relationship between the above systems are illustrated in Fig.7.

4.2 Target Year

The target year of the Improvement Programme is set up in the year of 2005. In order to accomplish the target of the Improvement Programme steadily and completely, implementation of the Programme is divided into three stages. The first stage, of which the target year is 1995, concentrates to improve quality of the hydro-meteorological data by strengthening the existing observation and data management system without large expansion of observation network. The second stage, of which the target year is 2000, is highlighted as "Observation System Expansion Stage" and targets to expand the observation network to the interim scale with introduction of new observation items such as sediment and water quality. The third stage, of which the target year is 2005, is the final stage of the Improvement Programme and aims to complete the observation network to the minimum required one and to improve the system of data dissemination to the users.

4.3 Long Term Programme, Immediate Programme and Model System

The Improvement Programme consists of the Long Term Programme and the Immediate Programme. The Long Term Programme is the long span master plan and the Improvement Programme itself. The Immediate Programme is the programme expected to be implemented firstly for the urgent improvement, which is the first stage of the Improvement Programme. In order to formulate more realistic and practicable Improvement Programme, the Model System is designed, established and operated.

5. EXAMINATION IN MODEL SYSTEM

5.1 Purpose of Model System

The Model System was planned and established, and has been operated for the purposes of: 1) attempting several ways of observation and data management and to help to formulate more practicable Long Term and Immediate Programmes, 2) transferring technology, 3) strengthening the existing systems by installing new gauges and new

computer facilities, and 4) accumulating reliable observation data by operating the Model System.

5.2 Study and Establishment of Model System

Two Model Basins, Kali Gandaki river and Jamuni river basins were chosen from two river groups originating from the Himalaya mountains and the Mahabharat mountains/Siwalik zone, respectively. The Kali Gandaki river basin was chosen taking account of 1) wide variation of rainfall amount, 2) existence of the prospective Kali Gandaki A hydropower project located just downstream, 3) few numbers of the existing river structures, and 4) operation of a station of the Snow and Glacier Hydrology Project in the basin. The Jamuni river basin was chosen considering 1) no gauge in the river, 2) few number of existing river structures, and 3) easy accessibility to Kathmandu. General maps of two Model Basins are given in Fig.8 and 9. Observation items are 1) daily and continuous precipitation, 2) daily and continuous water level, 3) discharge measurement, and 4) suspended sediment load sampling.

In the Kali Gandaki River basin of which the basin area is 7,110 km^2, 12 new recording raingauges were installed considering phenomena of south east monsoon, spatial and vertical uniformity of distribution, and steady operation by village people. 3 new recording water level gauges were installed at Tatopani, Kalleri and Setibeni considering changing point of runoff or river condition. In the Jamuni River basin, of which the basin area is 110 km^2, 2 new recording raingauges at Kolbhi and Chyuntaha and one new recording water level gauge at Chyuntaha were installed.

The selected types of raingauge are 13 Weighing-type and one Tipping bucket-type recording raingauge with a data logger at Pamdur. The selected types of water level gauge are 2 Pressure-type recording water level gauges with horizontal chart recorder at Tatopani and Setibeni, one Pressure-type recording water level gauge with a data logger at Kalleri, and one Float-type recording water level gauge at Chyuntaha. The selected types of current meter are one Price-type current meter for Setibeni, one Pigmy price-type current meter for Chyuntaha, and 3 Propeller-type current meters for Tatopani, Kalleri and Chyuntaha. 3 sets of bank operating double winch system at Tatopani, Kalleri and Chyuntaha are also selected.

The main work components of the Model Data Management System are 1) data collection by mail, wireless facility, and staff of the Regional Offices. 2) data processing at the Regional Office by using newly introduced computers, 3) data transfer, 4) data processing at the Central Office, 5) data storing in the storehouse and database, and 6) data

dissemination. The System was operated under the basic policy and conditions of 1) operation by the staff of the DHM, 2) introduction of 7 sets of new computers, and 3) use of the existing database softwares.

The following computers and data transfer devices were installed in the Central and Regional Offices in order to operate the Model System:

Instrument	Quantity	Office
Laptop type computer	6 sets	Regional Office
Desktop type computer	1 set	Central Office
Reader for data logger	2 sets	Western Regional Office

For the purpose of accurate and continuous observation, operation and maintenance manuals of existing and model observation instruments and facilities were prepared for observers and technical staffs of the DHM, respectively. In order to process and manage data observed in the existing and model observation stations smoothly and systematically with high accuracy, operation and maintenance manuals of data processing and management systems were provided for the technical staffs of the DHM. The introduction training, field observation training and computer training were performed by the Study Team to the DHM junior staffs for the operation of the Model System.

5.3 Operation of Model System

Some weighing type raingauges were not calibrated correctly due to inadequate check of instrument, which were already re-calibrated at the end of 1992 and June 1993. The field adjustment of weighing type raingauge and water level gauge such as time setting and zero adjustment was not conducted properly at most stations due to insufficient technical level of observers. Proper observation of ordinary raingauges and staff gauges was not carried out at some stations showing extraordinary values. The data logger with the tipping bucket type raingauge functioned well though it suggested a disadvantage that stored data were invisible at site for checking. Almost all the recording cards of ordinary raingauges and recording charts of automatic raingauges until April 1993 were collected in the Regional Offices as of June 1993 as seen in Fig.10. At Tatopani in the Kali Gandaki river, the installed pressure sensor was washed away due to attack of big boulders in August 1992. At Chyuntaha in the Jamuni river, the steel gauge well did not work due to shift of river course and a lot of sand deposit around the well during low water level for a few weeks in August 1992 and from April 1993. Records of staff gauge reading and recording charts of

automatic water level gauges observed until March or April 1993 were collected in the Regional Offices as of June 1993 as shown in Fig.11.

The installed bank operating cableway with double drum winch functioned well with safe and easy handling of equipments except for heavy winch operation by manual. For high flood measurement, the float method and the slope area method are also useful to supplement current metering method.

The situation of data collection in the Model Data Management System was investigated by referring register books in the Western and Mid Western Regional Offices. For both the above Regional Offices, around 58% of data of daily precipitation and staff gauge reading were collected within one month after observation and around 86% of the data within three months. One of the dominant reasons of the above delay is irregular data sending such as once five months by some observers. The trial of wireless communication in the Kali Gandaki river basin showed noisy and unstable transmission and suggested inadequacy of data sending by this communication method.

The laptop computers newly introduced in each Regional Office were operated well by the staffs of the Regional Office. However some future supports are required for them to guide and help for unexpected troubles. Almost staff gauge reading records until 1990 were entered in the Regional databases. The staff gauge records observed in the Model Observation System were not entered at the end of 1992 since the stations were not registered in the DHM. The entry work of these data just started after registration. The recording charts of water level gauges remained unprocessed. The daily rainfall data observed in the Model System were entered in the Regional database progressively. However, the rainfall recording charts were not processed. The number of discharge measurement is not enough to develop discharge rating curves in the Model System. Some sediment concentration was analysed in the Western Regional laboratory, though the data entry into computer was not yet done.

The visual data check and check by totalling were not carried out in the Regional Offices due to less understanding of necessity. The data check list was not used due to complicated form. No monitoring form and report was prepared in the Regional Office, which was to be sent to the Central Office. Some daily precipitation and water level data observed in the Model System and processed in the Regional Offices were transferred to the Central Office occasionally. On the other hand, no continuous record were processed and sent.

The data check by graphs and overall check were performed in the operation of the Model Data Management System. Especially, the graphical checking for water level data was useful. The precipitation data were checked by the overall checking method using isohyetal map or double mass, which was useful.

5.4 Evaluation of Model System

The tipping bucket type raingauge is recommendable from the viewpoints of stable operation and easy connection with data loggers. The weighing type raingauge is usable in snowfall area though careful calibration is required. The data logger is applicable and efficient for reliable data recording. The logger should have monitoring function to confirm exact data storing at site. The pressure sensor should be installed with careful site selection and designing of strong protection. The bank operating cableway is recommendable to be applied for safe and smooth discharge measurement. The float method and the slope area method are also effective for discharge measurement. The proper sediment sampling should incorporate with discharge measurement, point/depth integrated sampling, appropriate sampling section and frequent flood sampling.

Proper and regular calibration is required for the weighing type raingauge by technicians. The daily inspection and maintenance are also essential for this raingauge as well as water level gauges by the part-time observers. The operation and maintenance manuals should be modified and updated. Immediate repair of the station is also requisite to minimize data missing by improving managerial system. Adequate training is necessary in the field for observers to operate raingauges and water level gauges accurately. Training on calibration of the weighing type raingauge and operation of data logger as well as regular field observation is also important for technicians.

Data collection by mail and manpower of the Regional Office Staff is easy and reliable. The data collection to the Regional Office within one month may be achieved by further guidance and instruction to the part-time observers and effective schedule of site visits. The wireless communication is not recommendable. Computer equipment is powerful for data entry and processing. Continuous data entry is proposed to be carried out by using data loggers, digitizers, image scanners, etc. Precipitation data could be checked by comparing with those of adjacent stations and preparing isohyetal maps or double mass. The discharge measurement data can be checked by graphical method of stage-area or stage-velocity relationships or calculation of uniform/non-uniform flow. Water level and discharge data may be checked by hydrographs or runoff coefficient.

The original data and other important information should be stored orderly for future reference in conformity with manual and schedule. The online computer system between the Central Office and the Regional Offices will induce efficient data management and smooth activity control. Computer training is essential for the young engineers. Manuals and work schedule for data processing and management activities should be prepared and modified. The responsibility of each work is also clarified by the manuals. The monitoring and evaluation work should follow.

6. LONG TERM PROGRAMME

6.1 Precipitation Observation System

The minimum network of rainfall observation is proposed containing total 470 stations below the altitude of EL. 4,000 m with the density of 250 km^2/gauge in the mountainous area and 900 km^2/gauge in the Terai plain. The selected 470 raingauging stations consist of 252 existing, 14 model and 204 newly proposed stations, among which the recording stations are 60 in number, 14 existing, 14 model and 32 new stations. The network is shown in Fig.12. Point rainfall measurement is recommended in the Programme using ordinary and recording raingauges. Two types of recording raingauges, tipping bucket type and weighing type are proposed. The weighing type gauge is to be installed in high mountainous area above the altitude of EL. 2,000 m owing to its advantage of easy snowfall measurement. The following table shows a summary of raingauge installation:

	Instrument	Recording Method	Number of Station
(1)	Ordinary raingauge only	Once a day at 8:45	410
(2)	Tipping bucket type recording raingauge*	Data logger	40
(3)	Weighing type recording raingauge*	Weekly drum chart	20
	Total number of gauging station		470

* Each station is to be equipped with an ordinary raingauge.

In the weighing type recording gauging stations, recording charts are to be replaced by part-time observers once a week. Digital data stored in data loggers of the tipping bucket type gauge are to be collected by field technicians every three months. The observation manual should be reviewed.

6.2 Water Level Observation System

The minimum water level observation network, which consists of three types of gauging stations i.e. basic, primary and secondary hydrological station, is formulated with consideration of hydrological need, water usage/control aspect and the WMO norms for minimum density. Total 110 stations are proposed as shown below:

Number of basic hydrological station	10
Number of primary hydrological station	38
Number of secondary hydrological station	62
Total number of water level gauge	110

The selected 110 stations include 86 existing, 3 model observation and 21 newly proposed stations. The network is shown in Fig.13. Both of staff gauges and water level recorders are proposed in the Programme. Water level recorders are to be installed in the basic and primary stations. Commonly used float type water level recorder and pressure type water level recorder are recommended as shown below.

	Instrument	Recording Method	Number of Station
(1)	Staff gauge only	Three times a day at 8, 12 and 16	62
(2)	Float-type recording water level gauge*	Data logger	33
(3)	Pressure-type recording water level gague*	Data logger	15
Total number of gauging station			110

* Each station is to be equipped with staff gauge.

The stilling well for the float type gauge requires adequate design and construction for riverbed degradation and quick desilting action to cope with sedimentation inside the well. The data logger is to be equipped with large memory size and monitoring function to trace memory status.

Staff gauge reading is to be conducted by part-time observers three times a day. In addition to this regular reading, temporary staff gauge reading of flood is recommended with every hour reading and observation of water surface profile. Recording charts are to be replaced once a week and simple check of instrument and facility is to be made at that time. Digital data stored in data logger are to be collected by field technicians at the time of discharge measurement. In each basic hydrological station, it is recommended to assign two DHM

staffs. The observation manual should be reviewed. The general idea of the observation method is given in Table 2.

6.3 Discharge Measurement System

The following instruments are recommended in the Programme:

1) Cableway ; 40 bank operating double drum winch cableway and 60 single drum winch cableway with a cable car
2) Current meter ; 25 propeller-type current meters in the river with turbulent flow and 15 price-type current meters in gentle flow.
3) Flood Measurement ; Three sections of staff gauges are to be provided at the basic and primary stations for float method and slope area method. The peak water level gauges are proposed in the secondary station.

The field technicians will make discharge measurement. The minimum number of discharge measurement is recommended through consideration of the WMO recommendation and importance of station: 1) 36 times per year in the basic hydrological station, 2) 10 times per year in the primary station, 3) 6 times per year in the secondary station.

6.4 Sediment Sampling System

Twenty stations are selected and proposed as stations of sediment sampling network for the Programme, which include 10 basic stations and 10 primary stations as seen in Fig. 13. For sampling of suspended sediment and riverbed material, point and depth integrated samplers, pit sampling apparatus and turbidity meters are recommended to be installed. The point integrated method and indirect field measurement by using turbidity meters in the basic stations, and depth integrated method in the other stations are introduced. Regular measurement of once a week during dry season and once a day during monsoon season is proposed. Hourly sampling during floods is proposed. The sampling of riverbed material is to be made at least once a year in all the sediment observation stations. River profile and cross section surveys are recommended to be made once a year in representative sediment observation stations located in mountainous area. Sampling is to be made by part-time observers of the water level gauges or the technical staffs of the DHM in the basic hydrological stations regularly.

6.5 Water Quality Sampling System

Water quality observation is proposed to be conducted in 10 basic hydrological stations and one primary station in the Kathmandu Valley, total in 11 stations. The collection of depth

integrated samples in a single vertical is recommended. Daily and monthly samplings are proposed as routine observations. Technical staffs in the basic hydrological stations and the water quality laboratory take water samples for quality analysis.

6.6 Sediment Analysis System

The evaporation method and the filtration method are recommended for concentration analysis of suspended sediment load. The field measurement of sediment concentration by turbidity meter is to be introduced. The particle size analysis of suspended sediment load is newly to be introduced by applying visual accumulation (VA) method, sieve method and hydrometer method. Sieve analysis and some physical property analyses of riverbed material are also to be introduced in the Programme. The existing sediment laboratories are to be strengthened and expanded in the Central and Basin Offices. In each Basin laboratory, two DHM staffs are to be assigned. The existing laboratory equipment such as electric oven and balance should be repaired and strengthened. Guidance of proper sediment analysis by foreign experts and preparation of procedure manual are recommended.

6.7 Water Quality Analysis System

The following 11 parameters are chosen to be analysed in the Programme: Water temperature, pH-value, Conductivity, Dissolved oxygen (DO), Nitrogen Ammonia, Nitrogen Nitrate, Ortho-phosphate, Turbidity, Chlorine ion, Biochemical oxygen demand in 5 days (BOD), and Chemical oxygen demand (COD). Test kits applied for colorimetric analysis and portable probes applied for electrode method are proposed to be used. The samples of BOD and COD must be transported to the laboratory within 24 hours after sampling and be kept at a temperature of 3° to 4°C to slow down the biochemical oxidation processes. Routine observations are recommended. The water quality analysis will be carried out by technical staffs in the basic hydrological stations and the water quality laboratory of the Basin Office. One laboratory Chief and one Assistant in the laboratory are needed. The water quality laboratory is to be newly established in the strengthened sediment laboratories in the Central and Basin Offices. In the new laboratory, sufficient laboratory space and equipments such as BOD meter, COD meter and incubator, and test kits for the field measurements should be provided. Guidance of proper analysis by foreign experts and preparation of procedure manual are recommended.

6.8 Establishment System

The Establishment System includes structural design, civil construction work, instrument installation and their supervision of gauging station and laboratory. The network design and instrument selection will be conducted in the Data Quality Research System. In the Programme, the Establishment System is to be strengthened. The Establishment System will function in the Basin Office and technical staffs of the Basin Office take the responsibility of structural design and construction/installation works.

6.9 Inspection and Maintenance System

The daily/weekly inspection, which is general checking, is required to be performed by the part-time observers or staff of the basic hydrological station. The several monthly inspection is to be made by the well trained field and mechanical technicians. The annual inspection for overall checking of stations is required by the Hydrologist or Meteorologist. The adjustment and calibration of instruments are to be conducted by the well trained workshop mechanics in the field at the time of inspections. In each Basin workshop to be established in each Basin Office, two(2) mechanics are recommended to be employed.

Good and effective communication between the Central Office and each Basin Office is quite important for smooth inspection and maintenance work. The existing instrument workshop in the Central Office is to be reinforced by repairing machines and tools, supplying sufficient spare parts and spare instruments and reinforcing staffs. A full fledged standard current meter calibration facility is also recommended to be established for accurate discharge measurement.

6.10 Data Collection System

Objective of the Data Collection System is to collect observed or analysed hydro-meteorological data and information, and to send them to the Data Processing System after registration. The data and information are to be collected by mail, staff, telemeter and /or telephone. The records observed by ordinary/manual gauges are transferred by mail, which is useful, economical and easy. The records on charts and data loggers are collected by the DHM staffs as well as discharge measurement, survey and inspection records. The data observed at three basic stations in Karnali, Narayani and Koshi rivers are to be transmitted through telemetering system for accurate observation and proper maintenance. The data collected in the Branch Offices should be sent to Basin Offices after preliminary checking. Inventory of data collection is to be provided by using computer in the Basin and Central Office. Emergency information on stations, equipment, observers or others is

also collected by mail, telephone or telegraph, which should be transferred to the Inspection and Maintenance System and Progress Control/Quality Control Systems. The overall data management schedule is given in Fig. 14.

6.11 Data Processing System

Objective of the Data Processing System is to process collected data to the figures of user's need with entire checking, and to convey them including collected information on station and equipment to the Data Storing Satem. Before entering into computer collected data are to be checked primarily in the Basin Office. The data in paper form, chart, ram card or of analogue/digital sign are to be entered into computer in the Basin Offices. After data entry, they are to be checked by monitoring check, computer verification software, limit check or double entry check. After the above data check, data processing is to be made by using computers with three processing levels: the first level processing is independent one of each data, the second is processing by using two or more kinds of data such as discharge calculation, and the third is data book compilation. This data processing work is to be followed by further data checking in the Basin Office.

The processed data are to be transferred from the Basin Office to the Central Office through on-line system as well as original data to be sent by staff and final data check is carried out by the experienced staffs in the Central Office. In case some data errors are found, information on it is sent to the Basin Office and data are corrected in both of Basin and Central Offices. Total 26 sets of computers and accessories are recommended, among which 19 sets are new and 7 sets are model computers.

6.12 Data Storing System

Objective of the Data Storing System is to store original and processed data and collected information safely and systematically and to convey the data and information to the Data Dissemination System. The original and processed data and collected information are to be stored once a year with identification number in the Central Office. The System will store the original data and information in the storeroom and processed data in the database. Back-up for original and processed data is also to be kept in the optical disk.

6.13 Data Dissemination System

Objective of the Data Dissemination System is to disseminate necessary data to data users and also to the Data Quality Research System. The data dissemination is to be made by data book, on-line, floppy disk or photocopied list. Before dissemination, the System will

survey registration of user for on-line contact, user's request and also storing status of required data. And dissemination will be made by duplication of data in the Data Storing System.

6.14 Data Quality Research System

Objective of the Data Quality Research System is to improve quality of the hydro-meteorological data by proposing improvement plan based on related studies such as observation network study, investigation of instruments and other hydrological studies, and monitoring and reviewing activities of current observation and data management. Modification and improvement of operation, inspection and maintenance manuals of all the activities are also to be carried out.

6.15 Training System

Objective of the Training System is to train the DHM Staff to achieve smooth operation of observation and data management system and to obtain accurate data. In the Programme, regular and systematic training courses are to be introduced aiming to understand hydrology and meteorology, observation instruments and observation procedure, data processing, and computer operation. Not only on-the-job-training for the observers and field technicians also the training in the Training Center is proposed, which is to be established in the Central Office for efficient training. Foreign experts are also recommended.

6.16 Progress Control System

Objective of the Progress Control System is to monitor and control the progress of all the activities in order to disseminate data within next year. The Progress Control System will receive reports of present work status of all the other Systems every month and prepare monitoring report compiling the above reports in the Basin Office and the Central Office. The report transmitting is to be made by on-line between the Basin and Central Offices. The System will control the progress of the other Systems every month by comparing the actual work condition shown in the monitoring report and the schedule with giving necessary instructions. And the System will modify the annual schedule of all the activities when some defects or discrepancies occur.

6.17 Quality Control System

Objective of the Quality Control System is to monitor and control the quality of data and activity to disseminate reliable hydro-meteorological data. The Quality Control System will receive reports on present work method and condition of all the other Systems including data check every month and prepare monitoring report in the same manner as the Progress Control System. The System will, then, control the quality of data and activity on the basis of the prepared monitoring report and recommendation from the Data Quality Research System. The System will revise check list of quality control monitoring including data check list.

6.18 Evaluation System

Objective of the Evaluation System is to evaluate the current activities and to improve them. The evaluation is to be conducted on the basis of the monitoring reports prepared in the Progress and Quality Control Systems, user's demand obtained through dialogue and others. This evaluation may be accompanied with reward and punishment.

6.19 Organization and Staffing

In the Long Term Programme, a Central Office, four Basin Offices and ten Branch Offices are recommended as a new organization of the DHM from the viewpoints of more consistent, efficient and easy observation and data management as seen in Fig. 15. The Central Office will function in mainly management field to make progress and quality control, evaluation of system, data dissemination and staff training. The Basin Offices, which are recommended to be located in Nepalgunj, Pokhara, Kathmandu and Biratnagar, will function to operate stations and process data. The Branch Offices will maintain stations and collect data. Under the new organization, engineering staff of 138 persons are recommended as shown in Table 3.

6.20 Implementation Schedule and Project Cost

The Long Term Programme consists of three stages. The first stage is a programme up to 1995, which is considered as the Immediate Programme. The second stage is to be implemented between 1996 and 2000 and the third stage is from 2001 to 2005. Table 4 shows summary of the implementation schedule. The total project cost for the Long Term Programme is estimated to be around NRs. 878 millions including price escalation. Out of the total project cost, NRs. 633 millions will be needed in foreign currency and the rest of NRs. 245 millions in local currency. The estimated project cost is summarized below.

Item	Foreign Currency	Local Currency	Total Amount
- Observation	128,690	87,066	215,756
- Analysis of Sediment and Water Quality	3,056	0	3,056
- Management of Facilities	23,293	6,663	29,956
- Data Processing and Management	38,783	637	39,420
- Data Quality Improvement and Training	190,935	42,217	233,152
- Computer System	58,109	5,500	63,609
Sub-Total	442,866	142,083	584,949
- Administration and Engineering Service	75,107	4,032	79,139
- Contingency and Reserve	13,306	20,562	33,868
- Staff Training	0	2,424	2,424
Grand Total	531,278	169,102	700,380
- Price Escalation	101,611	76,130	177,741
Grand Total incl. Price Escalation	632,889	245,231	878,121

The annual operation, maintenance and replacement cost is estimated to be around NRs. 12.8 millions in the year of 2005, which is around 16 % of the projected annual budget of the DHM in the same year.

6.21 Evaluation of Proposed Long Term Programme

The quantitatively and qualitatively improved hydro-meteorological data by the implementation of the Programme will induce more reliable hydrological analysis, which leads to raise academic level and enable more proper and economical water resources development planning and designing. The estimated annual operation, maintenance and replacement cost of NRs. 12.8 millions in 2005 is considered not so large and it is concluded that the DHM could maintain the system after completion of the Programme. The case study on economic evaluation for the Programme was carried out and the result shows the internal rate of return of 30.2%, which indicates the Programme feasible.

7. IMMEDIATE PROGRAMME

7.1 Purpose and Basic Policies of Immediate Programme

The first priority should be put on the quality of the data instead of the quantity in stepwise improvement programme of the systems. The Immediate Programme, then, concentrates to improve quality of the hydro-meteorological data urgently by strengthening the existing hydro-meteorological observation and data management system without large physical expansion of the observation system. In order to attain the purposes to improve data quality as mentioned above, the Immediate Programme is formulated conforming to the following basic policies:

1) to focus four existing observation items , precipitation, water level, discharge and sediment observation.

2) to reinforce existing observation stations and laboratories with those operations.

3) to reinforce and improve existing data management system by delineation of activities, clarification of responsibility and expansion of computer system.

4) to reinforce systems for data quality improvement and monitoring of observation and data management activities by introduction of systematic procedure and training.

5) to reorganize a part of the structure of the DHM to enable and smoothen all the above works by introducing 16 systems among 18 systems proposed in the Long Term Programme.

7.2 Precipitation Observation System

The Immediate Programme concentrates to reinforce and repair existing precipitation observation system without expansion of the network which consists of 266 existing stations. The number of recording stations is to be increased up to 38, which are 14 existing, 14 model system and 10 newly proposed stations. Some repair and replacement of existing ordinary raingauges and replacement of 4 existing recording gauges are also required. Preparation of practical manuals and training are essential for part-time observers and field technicians. The tipping bucket-type gauge which equips both data logger and chart drum recorder is recommended to be installed in low land areas. In the mountainous and hilly areas located above EL. 2,000 m, the weighing-type gauge is recommended. Periodic inspection and maintenance are essential to operate it in good condition.

7.3 Water Level Observation System

Repair and reinforcement of the primary and secondary stations will be scheduled in the second and third stage of the Long Term Programme respectively. In the Immediate Programme, minimum required repairs are proposed such as installation of single winches, replacement of spare parts of damaged recorder, repair of cable and so on. Moreover, establishment of 10 basic hydrological stations is proposed by reinforcing the existing station. The following equipments and facilities should be completed at each basic hydrological station; staff gauge facility in 3 sections, water level recorder and facility, double drum winch cableway and propeller type current meter, point integrated sediment sampling equipment and insitu sediment observation device, and office building.

Station No. 390 in the Tinau river and No. 598 in the Kamala river are proposed to be shifted to appropriate site. Since it is difficult to select the suitable site for a gauge well for these stations , pressure-type gauge is proposed to be installed due to its advantage of easy installation work. The gauge well at Station No. 350 suffers from serious scouring problem, so pressure-type gauge is also proposed. Both of the existing and new recording gauges are recommended to equip data logger. Built-in display is suitable for monitor of pressure sensor and data logger. Manual revision is required in this Programme for proper operation.

7.4 Discharge Measurement System

The double drum winch cableway is proposed to all the basic hydrological stations except for No. 150, 280 and 598. At Station No. 150 and No. 280 at present double drum winch cableway is installed. A bridge located downstream the gauge is to be used for discharge measurement at Station No. 598. 20 propeller type and 5 price type current meters are to be introduced as the minimum requirement judging from the measurement schedule.

7.5 Sediment Sampling System

In the Immediate Programme, sediment sampling network which consists of 20 existing stations is recommended to be completed. The point integrated sampling is recommended at each basic station because more accurate data can be obtained generally in wide and deep river. Field measurement of turbidity is recommended as one of the effective sediment observation methods. This method will be introduced to the basic stations and Station No. 550.05. 8 point integrated samplers, 5 depth integrated samplers, and 10 turbidity meters at basic stations and 1 turbidity meter at No. 550.05 are to be provided.

7.6 Sediment Analysis System

Reinforcement of the existing sediment laboratory equipment is proposed and no addition of new observation item is recommended. The laboratory equipments such as electric oven, electric balance are to be provided. For proper and efficient sediment observation, manual and training are essential.

7.7 Establishment System

The Establishment System is proposed to be introduced in the Immediate Programme. The System will function in the Basin Office. The technical staffs of the Basin Office take the responsibility of structural design of stations and construction/installation works. Then, they should have knowledges in the field of civil engineering as well as those of instruments.

7.8 Inspection and Maintenance System

The daily/weekly inspection, several monthly inspection, the annual inspection and adjustment/calibration activities proposed to be carried out in the Basin Office in the Long Term Programme are to be introduced in the Immediate Programme to raise the data quality. Close and frequent communication should be achieved between the Central Office and each Basin Office in the Immediate Programme. Staffs of the Central Laboratory and workshop should give guidance and advices to the Basin Office. Sufficient spare parts and spare instruments, and machines/equipments should be provided. A calibration facility for current meter is recommended to be introduced. The electrical engineer is required to maintain electrical/electronic instruments such as data logger.

7.9 Data Collection System

The Data Collection System is proposed to be introduced. The objective, concept and procedure of the System in the Immediate Programme are principally the same as those in the Long Term Programme. This System will function mainly in the Basin Office and the Branch Office. The data and information are collected by mail, staff and/or telephone. The telemeter system is not to be introduced in the Immediate Programme considering the purpose and the surrounding condition. The procedure manual should be reviewed.

7.10 Data Processing System

The Data Processing System is proposed to be introduced. Almost all the works of this System are made in the Basin Office and the Central Office takes minor processing and

final data checking. The objective, concept and procedure of the System in the Immediate Programme are principally the same as those in the Long Term Programme. The data and information in paper form, chart or ram card of the data logger are to be entered into computer in the Basin Offices. The processed data and information as well as the original data are to be transferred from the Basin Office to the Central Office in the form of disk by the staffs of the Basin Office except for online system. The data checking work should be performed before and after data processing. The procedure manual should be reviewed.

7.11 Data Storing System

The Data Storing System is proposed to be introduced. This System will function mainly in the Central Office. The objective, concept and procedure of the System in the Immediate Programme are principally the same as those in the Long Term Programme. The original data and information will be stored in the storeroom. The processed data will be kept in the database. The optical disk for back-up of data will not be introduced in the Immediate Programme considering well balanced improvement. The procedure manual should be prepared.

7.12 Data Dissemination System

The Data Dissemination System is proposed to be introduced. This System will work mainly in the Central Office. The objective, concept and procedure of the System in the Immediate Programme are principally the same as those in the Long Term Programme. The data dissemination is to be made in the form of annual data book, floppy disk or photocopied list. The online dissemination is not proposed in the Immediate Programme. Then, the data dissemination from the Basin Office is not introduced in the Programme. The procedure manual should be prepared.

7.13 Data Quality Research System

The Data Quality Research System is proposed to be introduced urgently to raise data quality. This System will be operated in the Central Office. The objective, concept and procedure of the System proposed in the Immediate Programme are the same as those of the Long Term Programme.

7.14 Training System

In the Immediate Programme, a training center is proposed to be established in the DHM Central Office for proper, timely, systematic and specialized staff training. And the regular

or intensive training will be held in the new training center as well as in the field. The additional training will also be held for staffs who do not understand well the observation or data management procedure. Table 5 and 6 show the outline of the training menu.

7.15 Progress Control System

The Progress Control System should be introduced urgently in the Immediate Programme to achieve smooth operation of the other Systems to be established. The objective, concept and procedures of the System in the Immediate Programme are the same as those in the Long Term Programme. The System will receive reports of present work status of all the other Systems and control the progress every month. The annual report is to be prepared and submitted to the Evaluation System.

7.16 Quality Control System

The Quality Control System should also be established in the Immediate Programme for keeping and improving data quality. The objective, concept and procedure of the System in the Immediate Programme are the same as those in the Long Term Programme. The System will receive reports on present work method and condition of all the other Systems and control the quality of data and activity. The annual report on the quality of data and activity is to be prepared and submitted to the Evaluation System.

7.17 Evaluation System

The Evaluation System is essential and should be introduced urgently to evaluate the current activities and to improve them. The evaluation is to be conducted on the basis of the monitoring reports prepared in the Progress and Quality Control Systems, user's demand obtained through dialogue and others. The System proposed to be introduced in the Immediate Programme is the same as that of the Long Term Programme.

7.18 Proposed Computer Equipment

Computer equipments will be installed in the Central Office and each Basin Office in the Immediate Programme as shown in Fig. 16. The computers in the Central Office will be connected by the Local Area Network. Photocopy machine is also proposed to be installed for making back-up of the original data in the Basin Office. The following show the proposed number of computer of which 14 sets are new and 7 sets are model computers:

Office	System	Number of Computer
Central Office	for data base	1 set
	for data checking	4 sets
	for data dissemination	1 set
	for management	1 set
	for data entry	1 set
	for training	5 sets
each Basin Office	for data entry	1 set
	for data storage	1 set

7.19 Organization and Staff

The organization of the DHM proposed in the Immediate Programme is almost the same as that in the Long Term Programme, though the Basin workshop, water quality laboratory and telemeter system are not included in the Immediate Programme. The proposed organization will consist of the Central Office, four Basin Offices and 10 Branch Offices. The total number of 129 technical staffs is required.

7.20 Implementation Schedule and Project Cost

The Immediate Programme is to be implemented for 3 years from the year 1993 to 1995. Generally, in the first year in 1993, designing work of observation instruments, computers and civil structures and preparation of tender documents will be carried out. The tendering will start in early 1994. The main construction and installation work will be made in 1994 and 1995. The implementation schedule is shown in Fig. 17 to 19 for the observation system, the data management system and the civil construction respectively.

The total project cost for the Immediate Programme is estimated to be around NRs. 366 millions including price escalation. The foreign currency portion of the project cost is NRs. 275 millions and the local portion is NRs. 91 millions. The estimated cost for the Immediate Programme is given in Table 7. The annual disbursement schedule is tabulated below:

(Unit: 1,000 NRs)

Year	Investment			Operation & Maintenance	
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency
1993	16,928	0	16,928	0	0
1994	160,794	66,989	227,783	2,326	997
1995	96,976	23,599	120,575	3,267	1,400
Total	274,698	90,588	365,286	5,593	2,397

The annual operation, maintenance and replacement cost is about NRs. 4.7 millions in 1995 which is around 11 % of the projected annual budget of the DHM in the same year.

7.21 Evaluation of Proposed Immediate Programme

The Immediate Programme is designed to improve quality of the hydro-meteorological data by strengthening the existing hydro-meteorological observation and data management system without large expansion of observation equipment introduction. Then, the Programme mainly concentrates to designate the standardized procedure of the observation and data management and to clarify the responsibility of the Division, Section or person in charge. These items are considered to be the most fundamental ones and should be realized before implementing the succeeding stages of the Long Term Programme.

8. CONCLUSION AND RECOMMENDATION

(1) Improvement of the present system to observe and manage nationwide, continuous and reliable hydrological data is requisite for effective and economical planning and designing of water resources development, flood control and watershed management. The Long Term Programme is, then, proposed for the purpose of the above mentioned improvement work, and implementation of the Long Term Programme is keenly required.

(2) Out of the proposals of the Long Term Programme, the most fundamental items have been selected and the Immediate Programme is formulated. The improvement is considered as the first step before expanding observation and data management system. Then, the Immediate Programme should be implemented urgently.

TABLES

Table 1 RIVER BASIN AREA

	Name of River Basin	Basin Area (sq.km) within Nepal	Percentage of Basin Area within Nepal
I.	MAHAKALI RIVER	5,317	34%
II.	SOUTHERN BORDER RIVER GROUP NO. 1	3,811	100%
III.	KARNALI RIVER	(43,227)	
	1. HUMLA KARNALI	5,527	65%
	2. MUGU KARNALI	6,155	100%
	3. SINJATILA	3,252	100%
	4. SETI WEST	7,103	100%
	5. BHERI	13,867	100%
	6. KARNALI MAIN (OTHERS)	7,323	100%
IV.	BABAI RIVER	3,252	100%
V.	SOUTHERN BORDER RIVER GROUP NO. 2	948	100%
VI.	RAPTI (WEST) RIVER	6,215	100%
VII.	SOUTHERN BORDER RIVER GROUP NO. 3	4,849	100%
VIII.	NARAYANI/GANDAKI RIVER	(31,726)	
	1. TRISULI	3,622	57%
	2. BUDHI	3,621	73%
	3. MARSHANGDI	4,819	100%
	4. SETI (GANDAKI)	2,843	100%
	5. KALI GANDAKI	11,573	100%
	6. RAPTI (GANDAKI)	2,993	100%
	7. NARAYANI/GANDAKI MAIN (OTHERS)	2,255	100%
IX.	SOUTHERN BORDER RIVER GROUP NO. 4	3,502	100%
X	BAGMATI RIVER	3,681	100%
XI.	SOUTHERN BORDER RIVER GROUP NO. 5	3,013	100%
XII.	KAMALA RIVER	1,786	100%
XIII.	SOUTHERN BORDER RIVER GROUP NO. 6	1,896	100%
XIV.	SUN KOSHI/SAPTA KOSHI RIVER	(27,863)	
	1. BHOTE KOSHI	240	10%
	2. TAMA KOSHI	2,714	76%
	3. DUDH KOSHI	4,030	100%
	4. ARUN	5,248	15%
	5. TAMAR/TAMUR	6,125	100%
	6. SUN KOSHI MAIN (OTHERS)	9,506	100%
XV.	SOUTHERN BORDER RIVER GROUP NO. 7	3,462	100%
XVI	KANKAI RIVER	1,317	100%
XVII.	SOUTHERN BORDER RIVER GROUP NO. 8	1,316	100%
	TOTAL	147,181	

Table 2 SUMMARY OF OBSERVATION SYSTEM IN LONG TERM PROGRAMME

	Basic Station	Primary Station	Secondary Station
1) Observation instruments	i) Staff Gauge facility (3 Sections) ii) Water Level Recorder & Facility iii) Bank Operation Double drum winch cable way iv) Point integrated sample v) Portable meters and electrodes for water quality observation	i) Staff gauge facility (3 Sections) ii) Water level recorder & facility iii) Mountainous area →Double drum winch cable way (Bank operating) Terai area →Single drum winch cable way (with cable car) iv) Depth integrated sample v) Portable meters and electrodes for water quality observation	i) Staff gauge only (1 Section) ii) Single drum winch cable way with cable car
- Flood measurements			Peak water level gauge (Flood-crest gauge)
2) Water level observation			
- Regular	3 times per day (8, 12, 16)	3 times per day (8, 12, 16)	3 times per day (8, 12, 16)
- Flood	every hour during flood	every hour during flood	every hour during flood
3) Discharge measurement			
- Regular measurement	twice a week in dry season once a week in monsoon season A minimum total of 36 times per year	a minimum of 10 times per year	a minimum of 6 times per year
- Flood measurement	i) Shortened and optimized measurement by bank operating current meter ii) Float method iii) Slope area method	ditto	i) Float method ii) Slope area method
4) Sediment observation	Point integrated sampling	Depth integrated Sampling	no observation
- Regular	once a week in dry season once a day in monsoon season	ditto	
- Flood	every hour during flood	every hour during flood	
5) Water quality observation	Once a day for basic properties e.g. temperature, PH, conductivity turbidity, others per month	ditto (550.05 only)	no observation
6) Inspection and Maintenance	Stationed staffs carry out frequent inspection and continuous maintenance. Mechanic/Electric inspection is Carried out by mechanics once a year	Field technicians in branch office carry out inspection and mechanics conduct Mechanical/Electric Inspection once a year	ditto
7) Staff	Two stationed field technicians stay in all year	Field technicians in branch office	Field technicians in branch office

Table 3 TOTAL NUMBER OF REQUIRED ENGINEERING STAFFS (1/2)

Office		Remarks	Number of staffs
1.	Central Office		
1.1	Evaluation Division	Chief	1
1.2	Data Management Division	Chief	1
		Staff	2
1.2.1	Management Section		
1.2.1.1	Progress Control Unit		1
1.2.1.2	Quality Control Unit	Chief	1
		Data Processing Staff	4
		Observation	1
	Laboratory	Chief	1
		Sediment	2
		Water Quality	2
	Workshop	Chief	1
		Observation Equipment	4
		Computer Maintenance	2
	Sub-Total (1.2.1)		19
1.2.2	Data Arrangement Section	Chief	1
1.2.2.1	Data Storing Unit	Chief	1
		Data Arrangement	2
		Maintenance of Software	4
1.2.2.2	Data Dissemination Unit	Staff	2
	Sub-Total (1.2.2)		10
	Sub-Total in the Central Office		33
2.	Basin Office		
2.1	Far Western Basin Office	Chief	1
a	Data Arrangement Unit	Data Entry	1
		Data Processing	2
b	Observation Unit		4
c	Laboratory Unit		2
d	Workshop Unit		3
	Sub-Total (2.1)		13
2.2	Western Basin Office	Chief	1
a	Data Arrangement Unit	Data Entry	1
		Data Processing	2
b	Observation Unit		6
c	Laboratory Unit		2
d	Workshop Unit		2
	Sub-Total (2.2)		14
2.3	Central Basin Office	Chief	1
a	Data Arrangement Unit	Data Entry	1
		Data Processing	2
b	Observation Unit		2
c	Laboratory Unit		0
d	Workshop Unit		0
	Sub-Total (2.3)		6
2.4	Eastern Basin Office	Chief	1
a	Data Arrangement Unit	Data Entry	1
		Data Processing	2
b	Observation Unit		4
c	Laboratory Unit		2
d	Workshop Unit		2
	Sub-Total (2.4)		12

Table 3 TOTAL NUMBER OF REQUIRED ENGINEERING STAFFS (2/2)

Office		Remarks	Number of staffs
3.	Branch office		
3.1	Bannga		2
3.2	Chainpur		2
3.3	Simikot		2
3.4	Jumla		2
3.5	Musikot		2
3.6	Jomson		2
3.7	Simla		2
3.8	Okhalding		2
3.9	Khadbari		2
3.10	Taplejung		2
	Sub-Total (3)		20
4	Basic Station		
4.1	Mahakali		2
4.2	Kamali		2
4.3	Babai		2
4.4	West Rapti		2
4.5	Tamur		2
4.6	Gandaki		2
4.7	Bagmati		2
4.8	Kamara		2
4.9	Koshi		2
4.10	Kankai		2
	Sub-Total (4)		20
5	Synoptic Station		
5.1	Dandeldhura		2
5.2	Dhangadhi		2
5.3	Dipayal		2
5.4	Surkhet		2
5.5	Jumla		1
5.6	Ghorai		2
5.7	Bhairhawa		2
5.8	Pokhara		2
5.9	Simla		1
5.10	Kathmandu		2
5.11	Okhaldhunga		1
5.12	Dhankuta		2
5.13	Biratnagar		2
5.14	Taplejung		1
	Sub-Total (5)		20
	Grand-Total		138

Table 4 GENERAL ITEMS TO BE INCLUDED IN THE LONG TERM PROGRAMME (1/2)

FUNCTION OF SYSTEM	SUBSYSTEM AT				LONG TERM PROGRAMME			MODEL SYSTEM
	(1) OBSERVATION STATION	(2) BRANCH OFFICE	(3) BASIN OFFICE	(4) CENTRAL OFFICE	FIRST STAGE (Immediate Programme)	SECOND STAGE	THIRD STAGE	
					Urgent Improvement of Existing System till 1995 ` Elevation of Observation Accuracy ` Strengthening of Basin Office Work ` Improvement of Data Managing Work ` Completion of Processing of Existing Data ` Introduction of Basic Station	Initial Extension of Existing System till 2000 ` Expansion of Observation Network ` Introduction of New Observation and Management Items ` Elevation of Observation Accuracy ` Smoothening of Data Managing Work	Further Extension of Existing System till 2005 ` Expansion of Observation Network to Complete Min Network ` Improvement of Data Dissemination System ` Preparatory Study and Work for Further Stage	
(A) OBSERVATION	Precipitation Observation System				Reinforcement/Repair of Existing Raingauge * Repair of Existing Ordinary and Recording Raingauge * Addition of Recording Raingauges(10)	Extension of Raingauge Network (Initial stage:Focusing priority water resources project and scarce density) * Establishment of New Raingauge Stations (102) * Addition of Recording Raingauges(15)	Extension of Raingauge Network(Final stage:Completing min network) * Establishment of New Raingauge Stations(102) * Addition of Recording Raingauges(7)	* Plan of Distribution and Selection of Gauge Type * Installation,Operation and Maintenance
	Water Level Observation System				Repair of Existing Water Level Gauge and Introduction of Basic Stations * Minimum Required Repair of Existing Staff Gauges and Measuring Equipment * Establishment of Basic Stations(10)	Completion of Primary Station and Extension of Water Level Gauge Network * Repair/Reinforcement of Existing Equipments of Primary Stations(34) * Establishment of Primary Stations(4)	Completion of Secondary Station and Extension of Water Level Gauge Network * Repair/Reinforcement of Existing Equipments of Secondary Stations(45) * Establishment of Secondary Stations(17)	* Plan of Distribution and Selection of Gauge Type * Installation,Operation and Maintenance
	Discharge Measurement System				Repair of Existing Measuring Equipments * Minimum Required Repair of Existing Measuring Equipment * Repair and Addition of Current Meter	Completion of Measuring Equipments of Primary Stations * Improvement and Addition of Equipment of Primary Stations * Addition of Current Meter	Completion of Measuring Equipments of Secondary Stations * Improvement and Addition of Equipments of Secondary Stations	* Operation and Maintenance of Measuring Equipment * Introduction of Float and Slope-area Methods
	Sediment Sampling System				Completion of Sediment Observation Network * Repair/Reinforcement of Sediment Sampling Equipments	Introduction of Sampling of Riverbed Material * Introduction of Sampling Equipments		* Sampling and Guidance * Improvement of Sampling Method
	Water Quality Sampling System					Introduction of Water Quality Observation * Introduction of Field Test Kits and Sensor	Completion of Water Quality Observation Network * Addition of Field Test Kits and Sensors	
(B) SEDIMENT AND WATER QUALITY ANALYSIS	Sediment Analysis System		Sediment Analysis System		Reinforcement of Sediment Laboratory * Repair/Reinforcement of sediment Analysis Instrument	Introduction of Gradation Analysis * Installation of Equipments		
	Water Quality Analysis System		Water Quality Analysis System			Introduction of Water Quality Analysis * Introduction of Laboratory Equipment (BOD/COD)	Completion of Water Quality Analysis * Addition of Laboratory Equipment (BOD/COD)	
(C) ESTABLISHMENT, INSPECTION AND MAINTENANCE OF FACILITY			Establishment System		* Improvement of Establishment System			
		Inspection and Maintenance System	Inspection and Maintenance System		* Improvement of System	Introduction of Workshop in Basin Office * Installation of Mechanics and Tools		* Study on Inspection Manual
				Inspection and Maintenance System	* Establishment of Calibration Facility for Current Meter Reinforcement of Central Workshop * Reinforcement of Mechanics and Tools			

Table 4 GENERAL ITEMS TO BE INCLUDED IN THE LONG TERM PROGRAMME (2/2)

(D) DATA PROCESSING AND MANAGEMENT		Data Collection System	Data Collection System		* Mail/Staff	* Mail/Staff	* Mail/Staff Introduction of Telemetry System * Establishment of Telemetry Stations(3)	* Mail * Trial of Wireless Communication
			Data Processing System		* Introduction of Computer * Reinforcement of Processing System Introduction of Data Logger System * Introduction of Data Logging Equipment	Reinforcement of Computer Reinforcement of Data Logger System * Addition of Data Logging Equipment	* Reinforcement of Computer	* Introduction of New Computer * Data Processing and Checking
			Data Storing System		* Improvement of Storing System			
			Data Dissemination System				* Commencement of Data Dissemination	
				Data Processing System	* Collection by Floppy Disk * Mail/Staff * Introduction of Computer * Improvement of Processing System * Completion of Processing of Existing Data Backlog	* Collection by Floppy Disk * Mail/Staff * Reinforcement of Computer	* Data Transmission through Telecommunication Line, Mail/Staff * Introduction of On Line System between Regional and Central Offices * Study on Renewal of Computer	* Data Collection by Floppy Disk * Introduction of New Computer * Data Processing and Checking
				Data Storing System	* Establishment of Storeroom * Improvement of Storing System		* Improvement of Storing System	
				Data Dissemination System	* Improvement of Dissemination System		* Publication of Data Book for Previous Year's Data	
(E) DATA QUALITY IMPROVEMENT AND TRAINING				Data Quality Research System	* Introduction of Research System * Improvement of Manual			
		Training System	Training System		* Invitation of Foreign Expert * On The Job Training	* Invitation of Foreign Expert * On The Job Training	* Invitation of Foreign Expert * On The Job Training	* On The Job Training * Lecture and Guidance
				Training System	* Invitation of Foreign Expert * Establishment of Training Center * Regular Training * Training in Manufacturer	* Invitation of Foreign Expert * Regular Training * Training in Manufacturer	* Invitation of Foreign Expert * Regular Training * Training in Manufacturer	* Lecture and Guidance
(F) MONITORING AND EVALUATION OF ACTIVITIES			Progress Control System	Progress Control System	* Improvement of Progress Control System			* Establishment of Organization and Schedule
			Quality Control System	Quality Control System	* Improvement of Quality Control System			
				Evaluation System	* Improvement of Evaluation System			

Table 5 GENERAL ITEMS OF FIELD TRAINING

Person to be trained	Item to be trained	Content
Field technician	1. Precipitation Observation	• Installation observation method operation of instrument
	2. Water level observation	• ditto
	Data processing	
	3. Discharge measurement	• ditto (including flood measurement)
	4. Sediment observation	• Observation method, operation of instrument
	5. Inspection of the station	• Method, reporting
	6. Maintenance of instruments and facilities (including simple adjustment/ calibration of instrument)	• Method (including minor repair)
	7. Civil construction works related observation system	• Construction/Repair of facilities
		• Planning and Cost estimation
		• Design, drawing
	8. Survey	• Field practice such as levelling, ross section, theodlite survey etc.
		• Mapping and drawing, Survey method
Part time Observer	1. Precipitation observation	• Observation method
		• Operation of instrument
	2. Water level observation	• ditto
	3. Sediment Sampling	• ditto
	4. Daily inspection of the Station	• method (including minor repair)
	5. Maintenance of instruments and facilities	• method

Table 6 TRAINING ITEM FOR IMMEDIATE PROGRAMME (1/2)

Training Item	Training Hour				
	N	F	J	S	E
1. Introduction					
1.1 Outline of DHM	1				
1.2 Observation of DHM	1	1			
1.3 Data Processing in DHM	1		1		
1.4 Data Checking in DHM	1			1	
1.5 Analysis					1
Sub-Total	4	1	1	1	1
2. Observation					
2.1 Precipitation					
2.2.1 General	1	1			
2.2.2 Observation Network					3
2.2.3 Manual Gauge		1	1		
2.2.4 Recording Gauge (Weighting Type)		5	1		5
2.2.5 Recording Gauge (Other Type)					
2.2 Snowfall					1
2.3 Rainfall					
2.3.1 Radar					5
2.3.2 Satellite					1
2.4 Snow cover			1		
2.5 Evaluation			1		
2.6 Water Level					
2.6.1 General	1	1	1		
2.6.2 Observation Network					3
2.6.3 Manual Gauge		1	1		
2.6.4 Recording Gauge (Float Type)		5	1		
2.6.5 Recording Gauge (Other Type)					5
2.7 Discharge Measurement					
2.7.1 General	1	1	1		
2.7.2 Current Meter		5	5		
2.7.3 Float					5
2.7.4 Other Way					5
2.8 Sediment					
2.8.1 General	1				
2.8.2 Selection of site					2
2.8.3 Suspended-Sediment					
2.8.3.1 Sampling		1	1		
2.8.3.2 Sediment Concentration				5	
2.8.3.3 Suspended-Sediment Discharge					2
Sub-Total	4	21	14	5	37

Table 6 TRAINING ITEM FOR IMMEDIATE PROGRAMME (2/2)

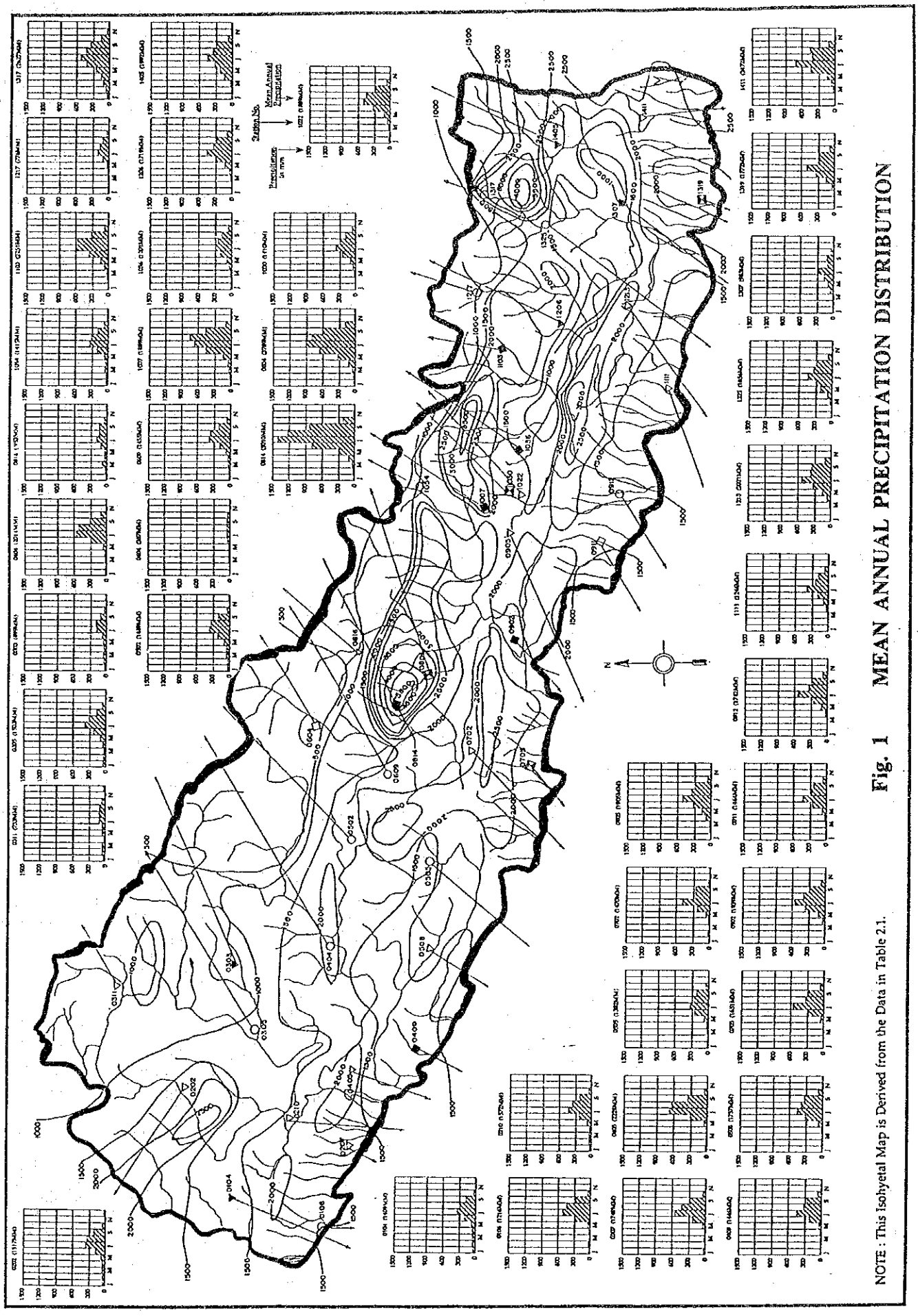
Training Item	Training Hour				
	N	F	J	S	E
3. Data Processing					
3.1 Computer					
3.1.1 General Knowledge on Computer			1	1	
3.1.2 General Knowledge on Software			1	1	
3.1.3 Data Base Software				15	
3.1.4 Application Software				30	30
3.2 Procedure					
3.2.1 General				1	
3.2.2 Preliminary Data Checking				1	1
3.2.3 Data Entry				1	
3.2.4 Determination of Rating Curve				5	5
3.2.5 Estimation of Discharge				1	1
3.2.6 Data Processing Checking					5
3.2.7 Overall Checking					15
3.2.8 Final Checking					1
3.2.9 Deal with Error					1
3.2.10 Emergency Case		1		1	1
Sub-Total	0	1	3	57	60
4. Basic Knowledge					
4.1 Meteorology				5	
4.2 Statistics in Hydrology Analysis				5	
4.3 Precipitation				5	
4.4 Hydrograph				5	
4.5 Hydrologic Losses				5	
4.6 Stream Flow				5	
Sub-Total				30	
5. Analysis					
5.1 General					1
5.2 Precipitation					
5.2.1 Mean Area Precipitation					5
5.2.2 Depth-Area-Duration Analysis					5
5.2.3 Probable Maximum Precipitation					5
5.2.4 Rainfall Frequency					5
5.2.5 Rainfall Intensities					5
5.3 Stream Flow					
5.3.1 Low Flow Analysis					15
5.3.2 Flood Frequency					15
5.3.3 Runoff Relations with Rainfall					15
Sub-Total					71
6. Management					
6.1 General		1	1	1	1
6.2 How to Instruct Observer				1	
6.3 Management on System					5
Sub-Total		1	1	2	7
Grand Total	8	24	19	95	176

Note N : Newly employed staff
F : Field assistant
J : Junior hydro-meteorological assistant
S : Senior hydro-meteorological assistant
E : Engineer

Table 7 COST ESTIMATION FOR IMMEDIATE PROGRAMME

	WORK ITEM		F/C	L/C	1993		1994		1995		Total	
					F/C	L/C	F/C	L/C	F/C	L/C	F/C	L/C
(A) Observation	(1) Rainfall Observation	Manual Raingauge		Manual Gauge / Foundation				660		660	0	1,320
		Tipping Bucket Type	Raingauge / Recorder / Data Logger	Manual Gauge / Foundation			6,370	600		400	6,370	1,000
		Weighing Type	Raingauge / Recorder	Manual Gauge / Foundation			192				192	0
		Spare Inst. / Parts etc.	Spare Parts	Repair / Manual Gauge			656				656	0
	(2) Water Level Observation	Staff Gauge		Plate / Foundation				126		234	0	360
		Float-type	Recorder / Data Logger	Gauge Well / Gauge House / Clearing / Repairing			1,108	13		97	1,108	110
		Pressure-type	W.L. Gauge / Data Logger	Protection Pipe / GI Pipe			1,524	121		242	1,524	363
		Peak Water Level Gauge		GI Pipe / Foundation							0	0
		Survey Instrument	Level / Transit				2,250				2,250	0
		Spare Inst. / Parts etc.	Spare Parts / Data Logger				681				681	0
	(3) Discharge Measurement	Single Winch		Tower / Cable / Winch / Cableway / Foundation				3,094			0	3,094
		Double Winch	Double Winch / Suspension Wire	Operation House / Anchor Block / Wire			10,576	5,970			10,576	5,970
		Propeller-type Current Meter	Body / Weight / Counter				15,490				15,490	0
		Price-type Current Meter	Body / Weight / Counter				2,580				2,580	0
		Spare Inst. / Parts etc.	Spare Parts				1,807				1,807	0
	(4) Sediment Observation	Point Integrated Sampling	Sampler Bottle / Tubidity Meter				6,352				6,352	0
		Depth Integrated Sampling	Sampler Bottle / Tubidity Meter				1,105				1,105	0
		Spare Inst. / Parts etc.	Spare Parts				746				746	0
	(5) Water Quality Observation	Field Test Kit									0	0
		Sensor									0	0
	(6) Basic Station	Office		Building				1,110		740	0	1,850
Sub - Total (A)					0	0	51,437	11,094	0	2,373	51,437	14,067
(B) Analysis of Sediment and Water quality	(1) Sediment Analysis	Sediment Labo.	Laboratory Equip.				1,220				1,220	0
	(2) Water quality Analysis	Water quality Labo.	Laboratory Equip.								0	0
Sub - Total (B)					0	0	1,220	0	0	0	1,220	0
(C) Management of Facility	(1) Maintenance of Station	Regional Workshop	Repair Equip. and Tools	Repair Tools / Building / Furniture							0	0
	(2) Repair of Equip.	Central Workshop	Repair Equip. and Tools	Repair Tools			1,108				1,108	0
	(3) Current Meter Calibration Facility		Calibration Equip.	Calibration Tank			21,073	3,998		2,665	21,073	6,663
Sub - Total (C)					0	0	22,181	3,998	0	2,665	22,181	6,663
(D) Data Processing and Management	(1) Data Collection	Telemetry	Telemetry Equip.	Building / Foundation							0	0
	(2) Data Processing	Data Logger System	Reader / Memory Card				4,954				4,954	0
Sub - Total (D)					0	0	4,954	0	0	0	4,954	0
(E) Data Quality Improvement and Training	(1) Staff Training	Invitation of Foreign Expert					9,192		18,384		27,576	0
		Training in Manufacture					733		733		1,466	0
		Attendance of International Course					366		366		732	0
	(2) Training Center		Computer Equip / Observation Inst. / Building	Building / Furniture / Land 5,000 m2			20,477	33,349	28,121	8,866	48,598	42,217
Sub - Total (E)					0	0	30,768	33,349	47,604	8,866	78,372	42,217
(F) Computer System	(1) Design and Programming				3,129		8,344	2,500	6,258	2,500	17,731	5,000
	(2) Computer Instrument						3,951		5,550		9,501	0
	(3) Soft Ware						1,942		3,281		5,223	0
	(4) Furniture and Installation						350		350	500	700	500
	(5) Staff Training								5,215		5,215	0
Sub - Total (F)					3,129	0	14,587	2,500	20,654	3,000	38,370	5,500
Sub - Total (A+B+C+D+E+F)					3,129	0	125,147	51,543	68,258	16,904	196,534	68,447
Administration and Engineering Service					13,799	0	24,137	1,556	19,537	517	57,473	2,073
Contingency and Reserve					0	0	5,326	7,356	1,865	2,161	7,191	9,517
Staff Training						0		1,003		281	0	1,284
Grand - Total					16,928	0	154,610	61,458	89,660	19,863	261,198	81,321
Price Escalation							6,184	5,531	7,316	3,736	13,501	9,267
Grand - Tot Total (With Escalation)					16,928	0	160,794	66,989	96,976	23,599	274,698	90,588
O. M. R. (Operation, Maintenance and Replacement)					0	0	2,326	997	3,267	1,400	5,593	2,397

FIGURES



NOTE : This Isohyetal Map is Derived from the Data in Table 2.1.

Fig. 1 MEAN ANNUAL PRECIPITATION DISTRIBUTION

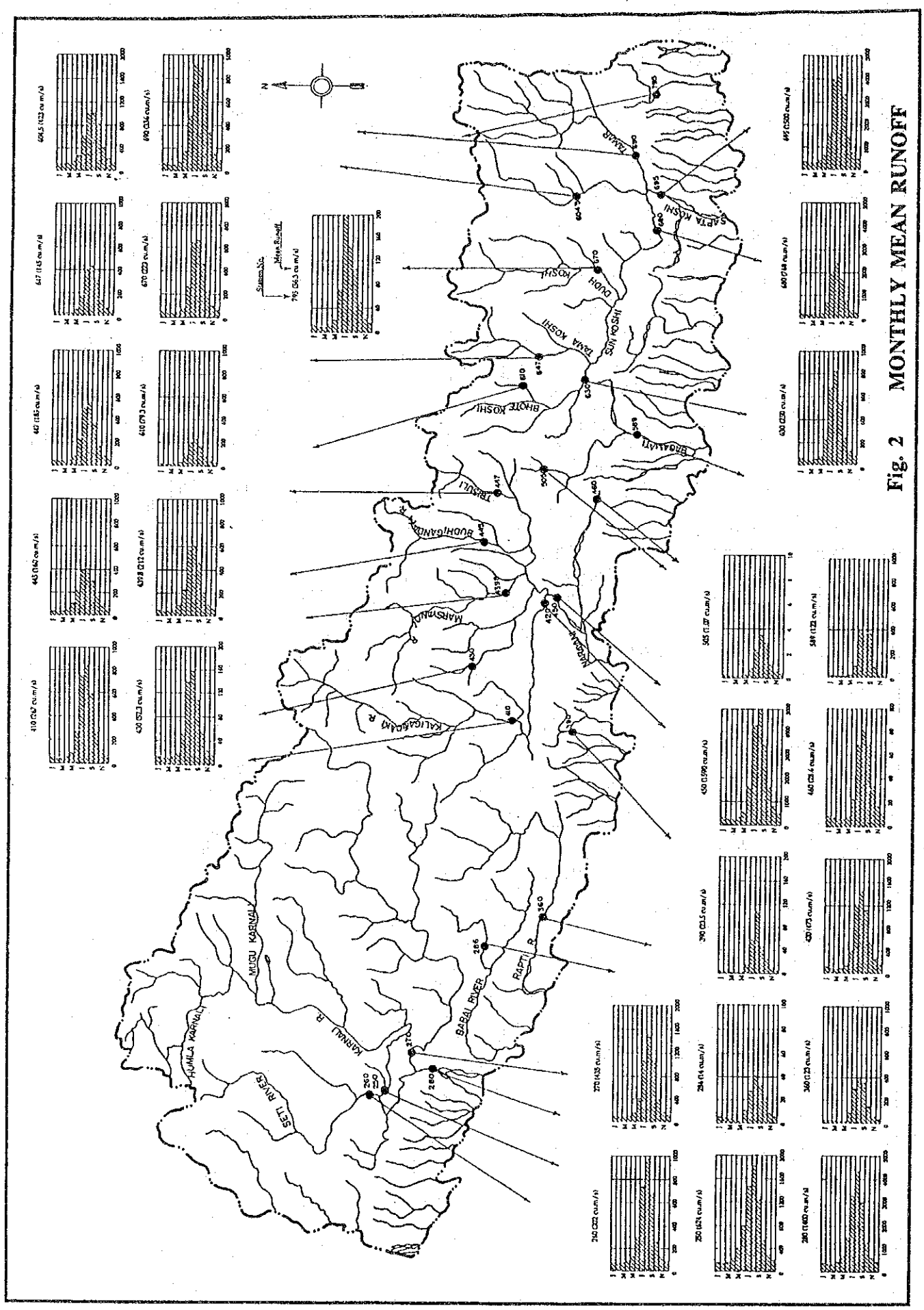


Fig. 2 MONTHLY MEAN RUNOFF

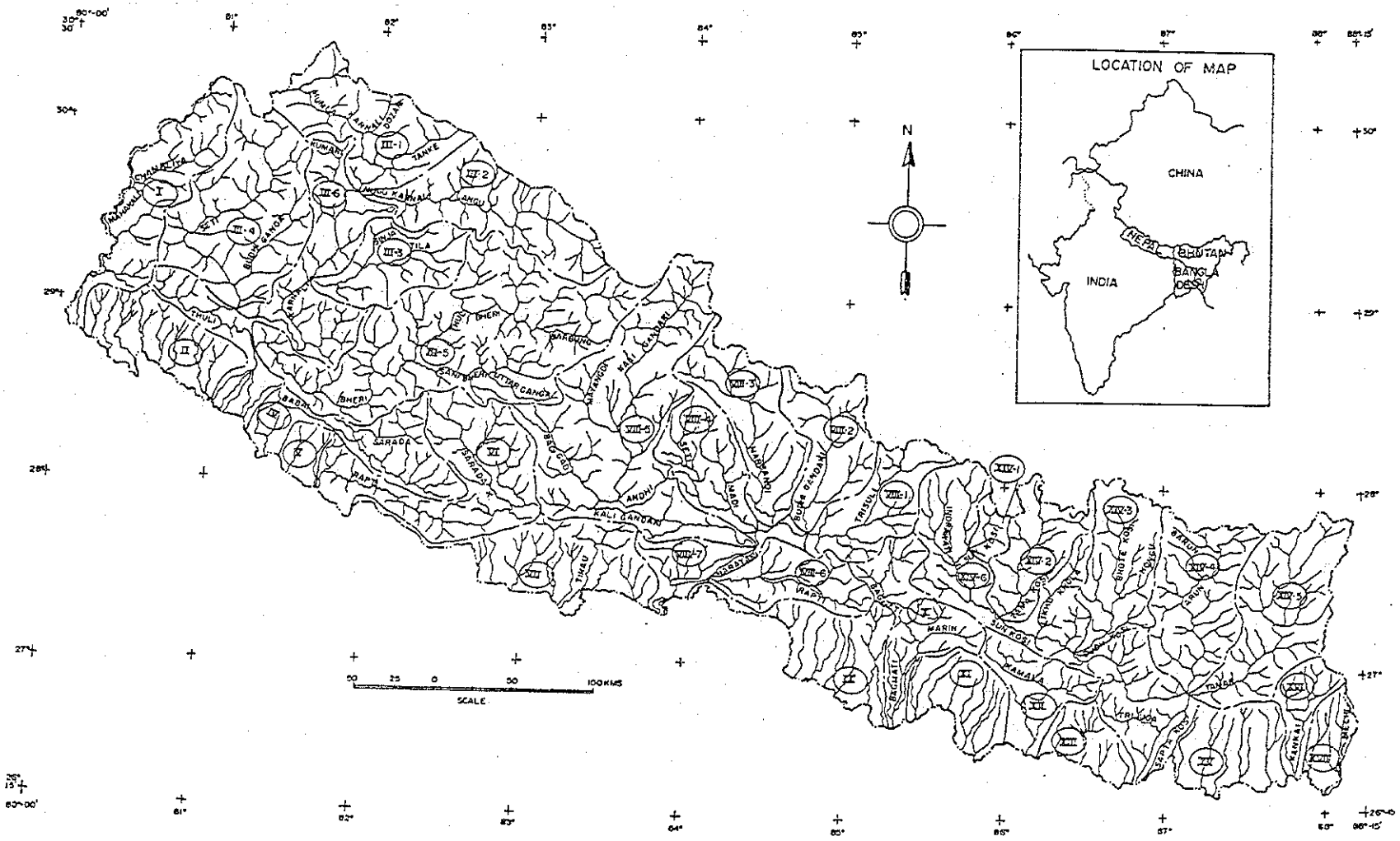
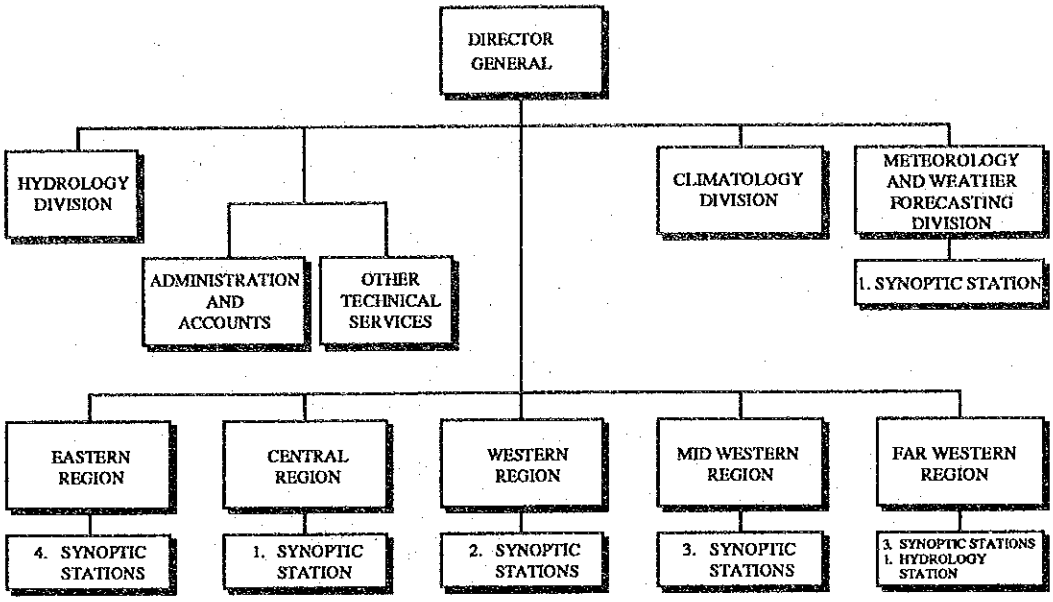
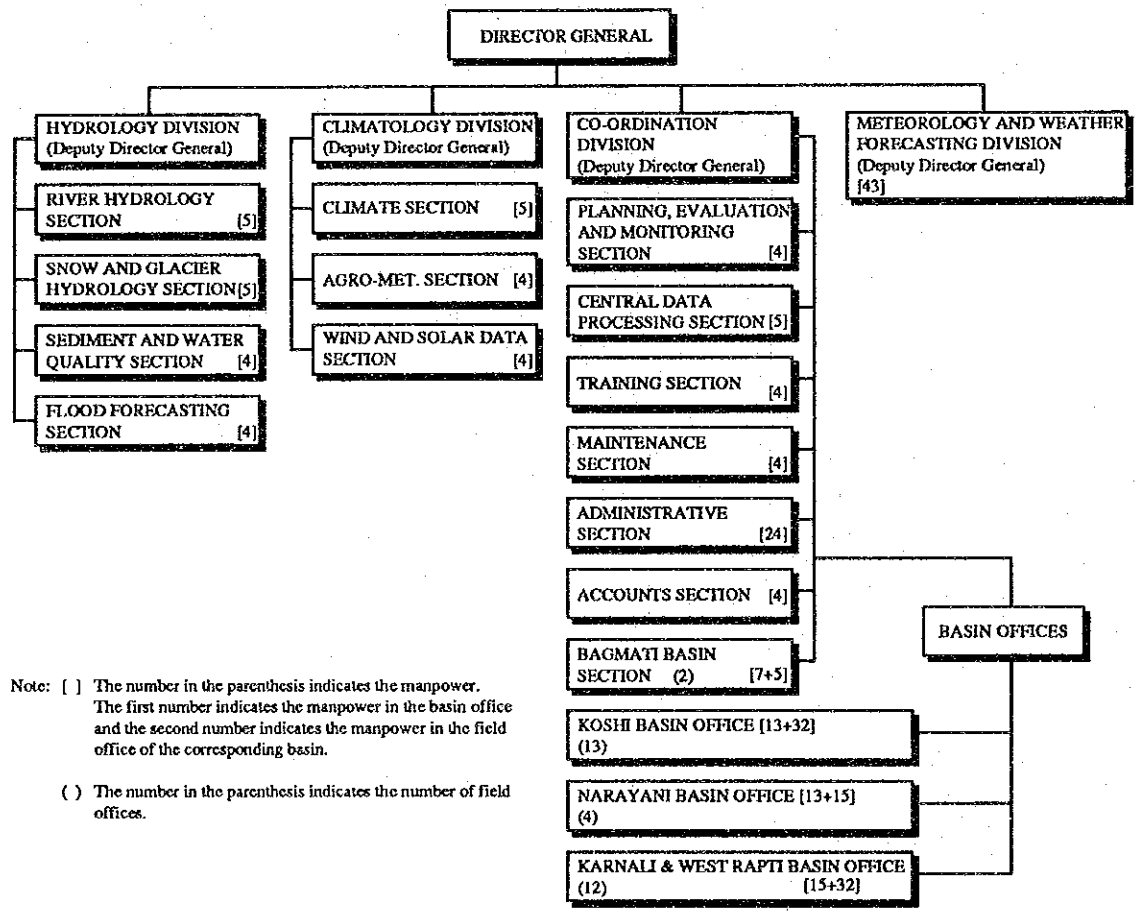


Fig. 3 RIVER AND RIVER BASIN IN NEPAL

NOTE : See Table 3.1 for Basin Name.



Organization Effective till Mid-July 1993



Note: [ ] The number in the parenthesis indicates the manpower. The first number indicates the manpower in the basin office and the second number indicates the manpower in the field office of the corresponding basin.

( ) The number in the parenthesis indicates the number of field offices.

Organization Effective after Mid-July 1993

Fig. 4 ORGANIZATION CHART OF DHM

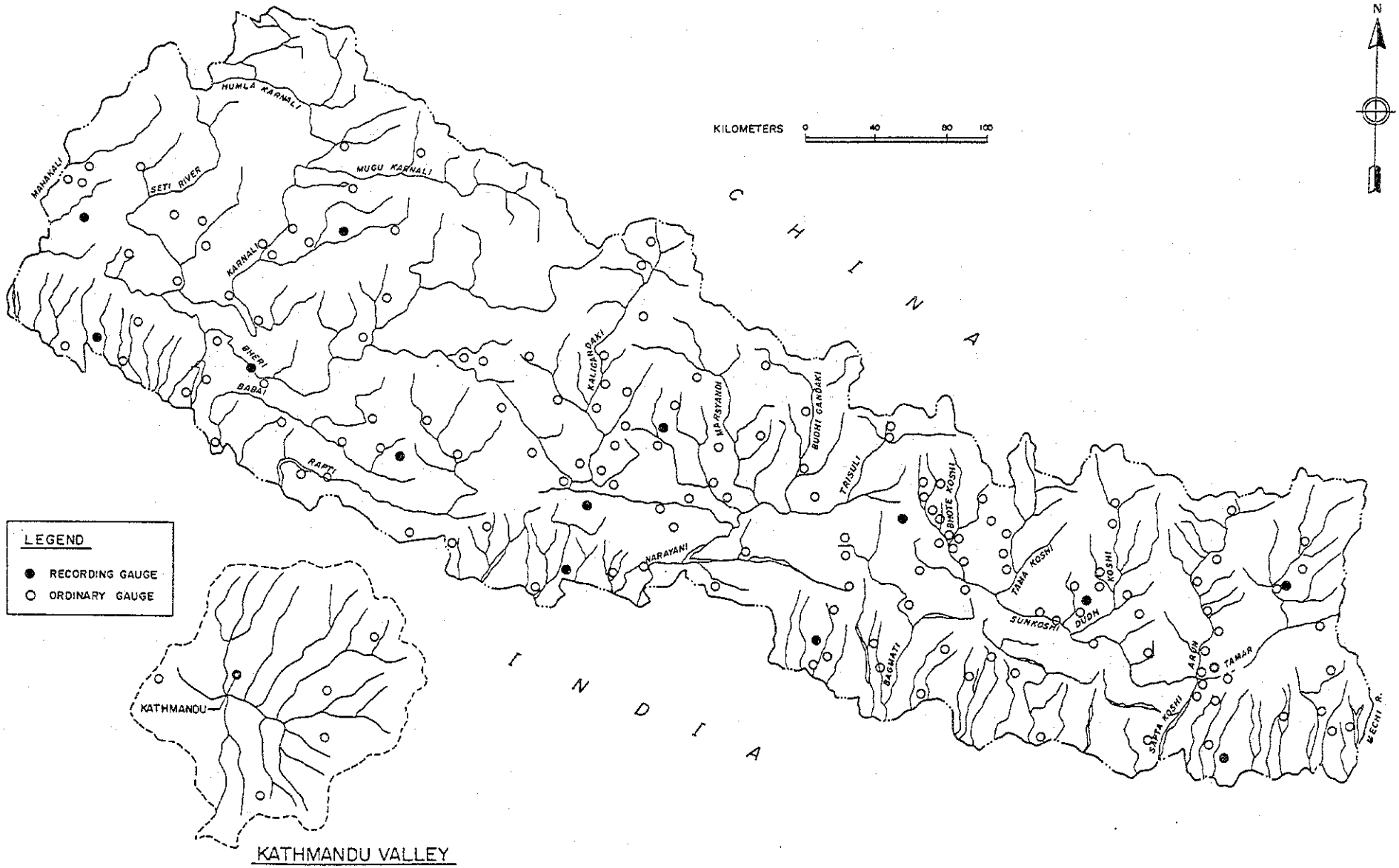


Fig. 5 PRECIPITATION STATIONS

F- 5

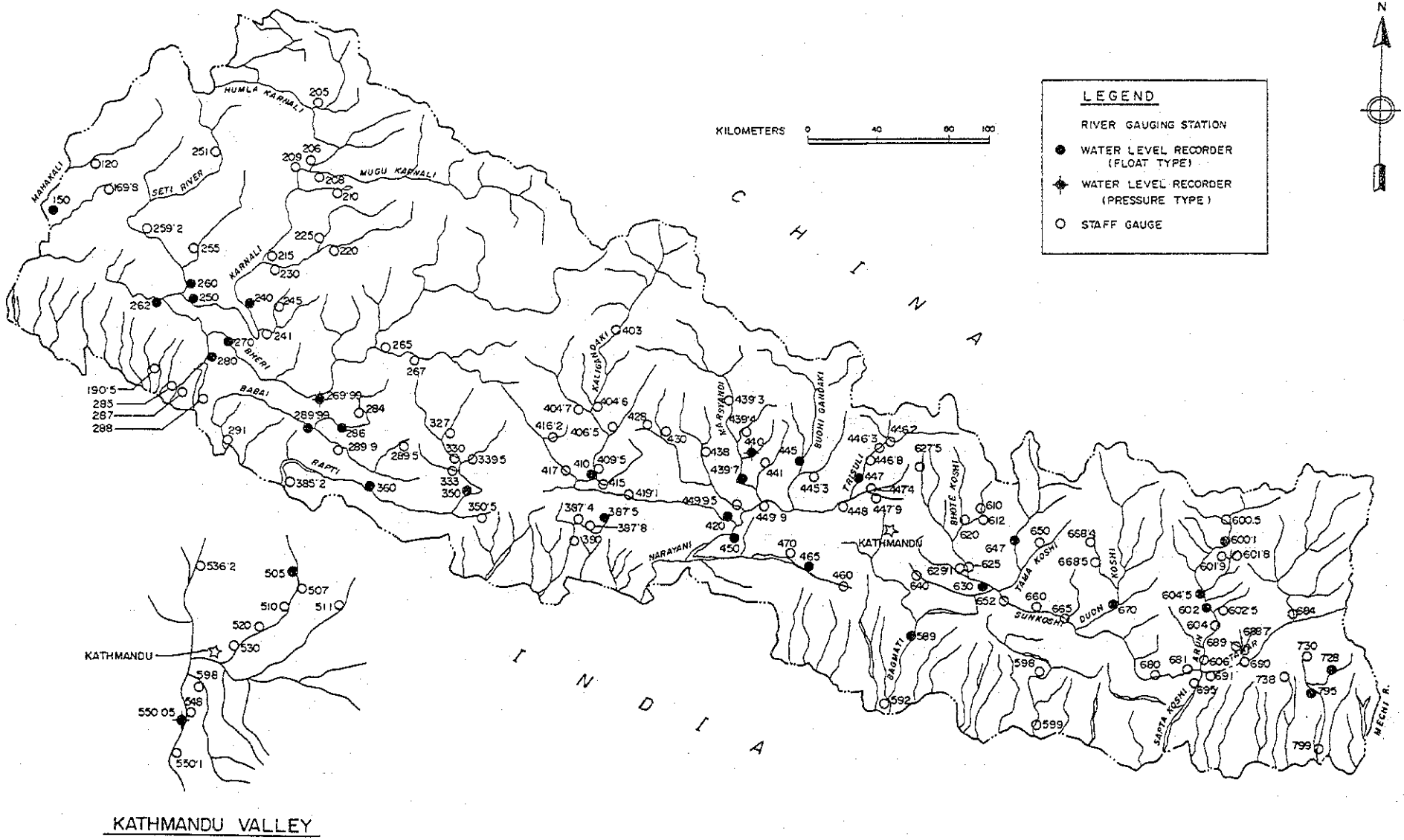
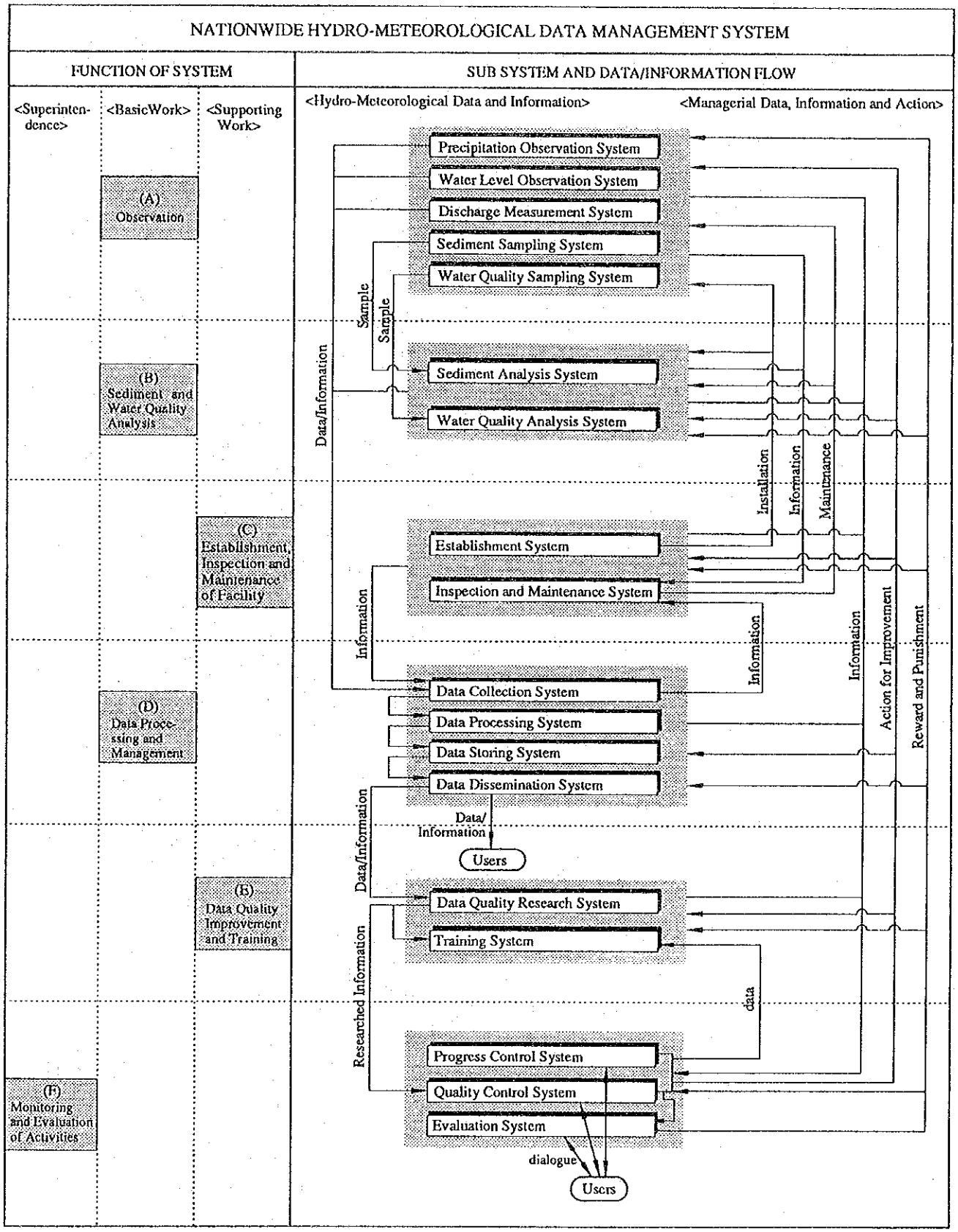


Fig. 6 HYDROLOGICAL NETWORK IN NEPAL

Fig. 7 NATIONWIDE HYDRO-METEOROLOGICAL DATA MANAGEMENT SYSTEM IN THE IMPROVEMENT PROGRAMME



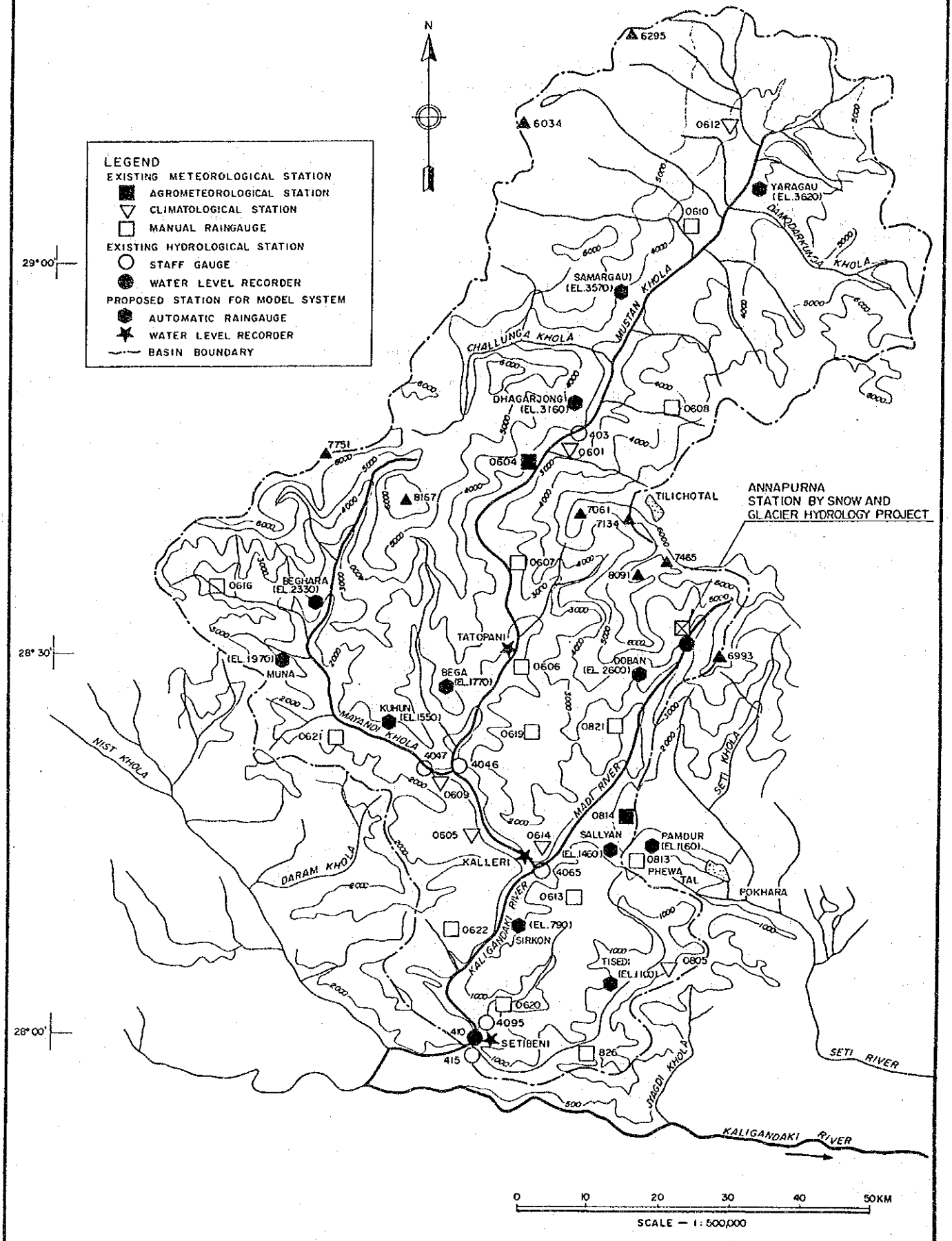


Fig. 8 KALI GANDAKI RIVER BASIN (MODEL BASIN)

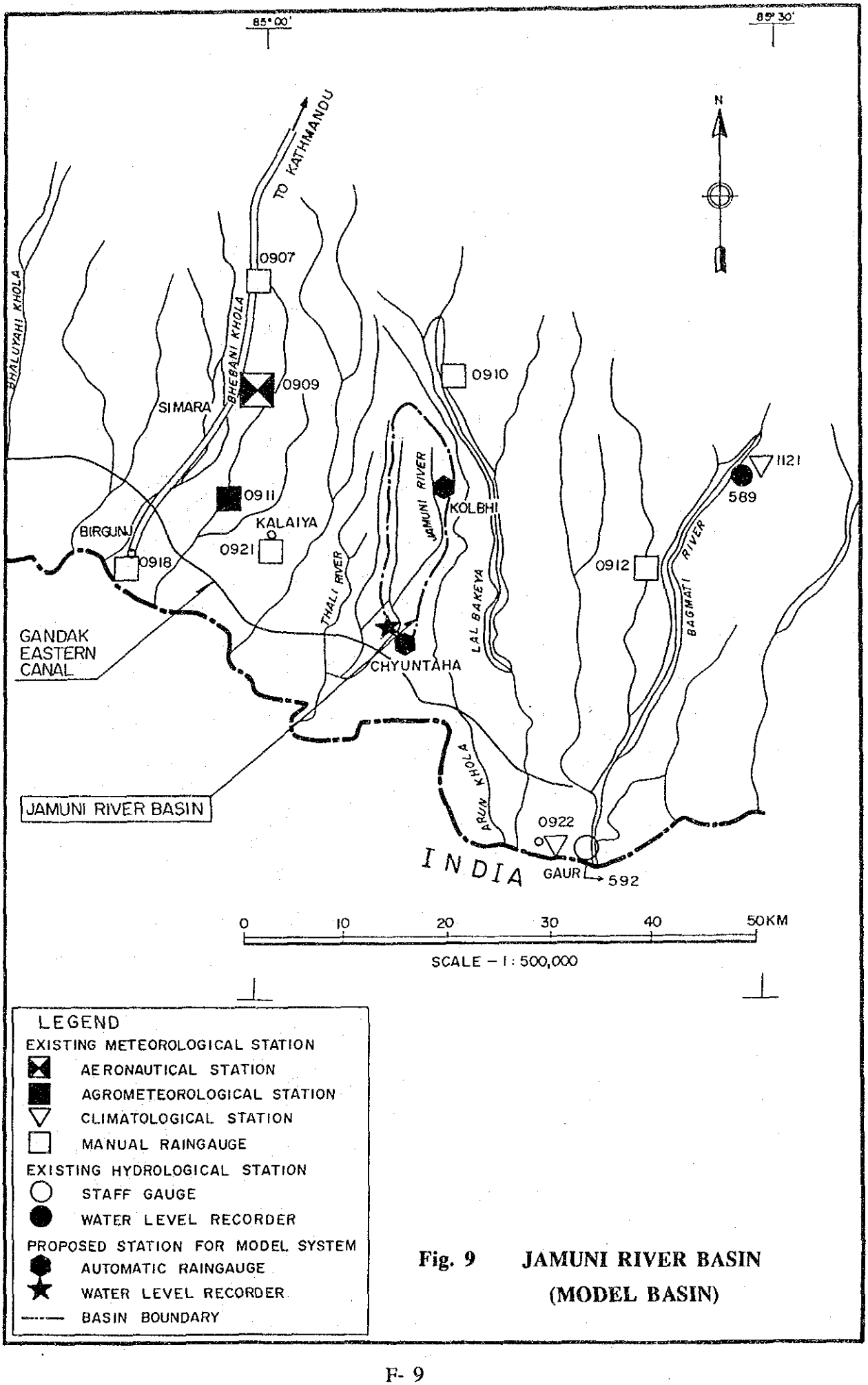


Fig. 9 JAMUNI RIVER BASIN (MODEL BASIN)