No.

The Department of Water Induced Disaster Prevention, Ministry of Water Resources
The Department of Roads, Ministry of Physical Planning and Works
The Republic of Nepal

THE STUDY ON DISASTER RISK MANAGEMENT FOR NARAYANGHARH – MUGLING HIGHWAY

FINAL REPORT

Volume III
Data and Drawing

February 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

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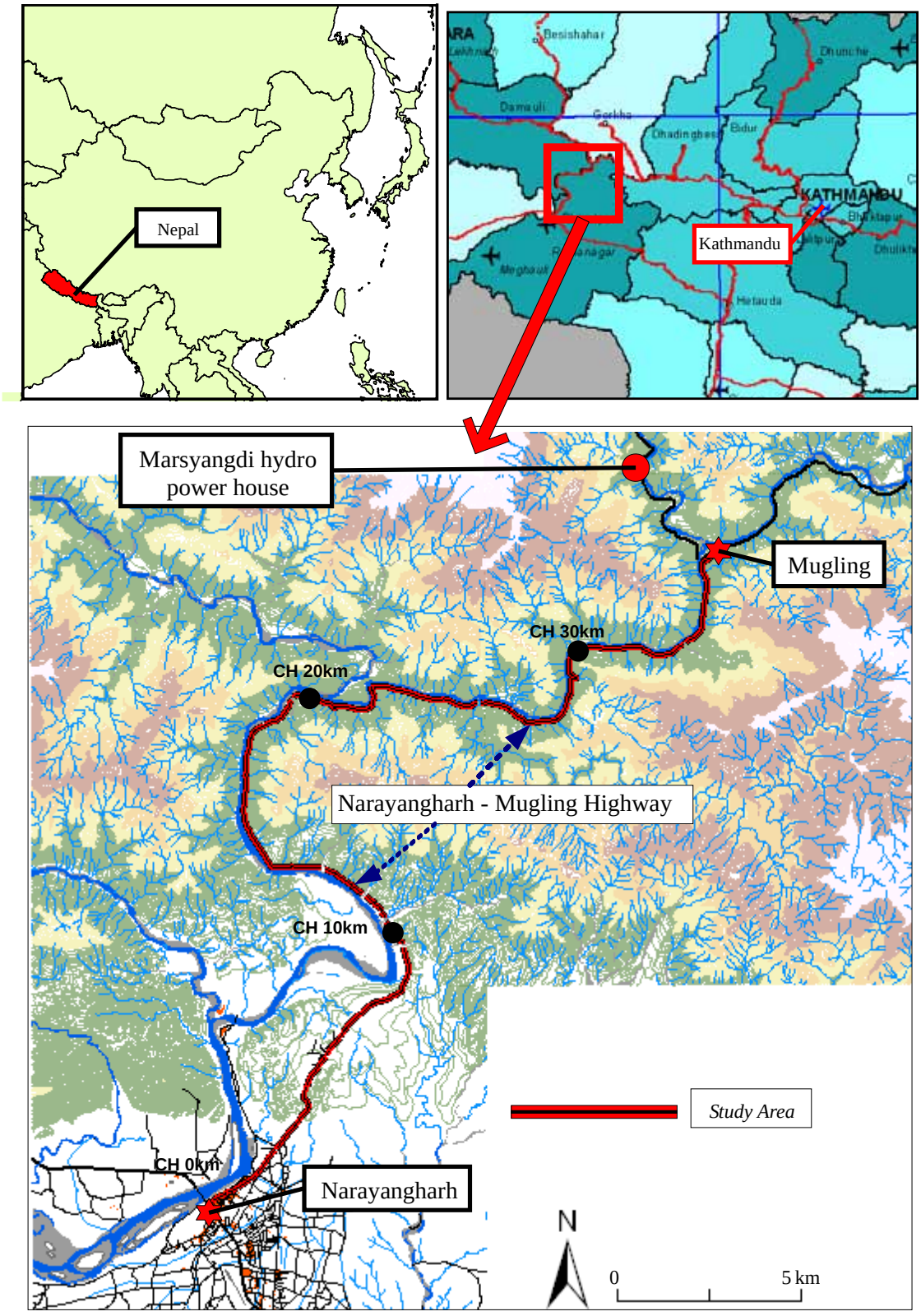
COMPOSITION OF REPORTS

Volume	Report Name	Language
Volume I	Summary	English
Volume II	Main Report	English
Volume III	Data and Drawing	English
Volume IV	Technical Guide	English



Location Map of the Study Area

Definition of Terms for Risk Assessment

Terms		Definitions
Disturbance	:	Deformation of the slope and/or road structures or slope collapse which has not reached the road.
Road Closure Disaster [RCD]	:	A disaster which causes closure of the whole or partial width of the road Deformations and collapses that do not close the road are not necessarily regarded as a RCD but just as a 'Disturbance'.
Loss	:	Monetary amount of damage caused by a disaster, specifically defined as the sum of the reopening cost, human lives lost, vehicle lost and losses of traffic suspension.
Risk	:	The total damage characterized by the potential frequency and magnitude of the disaster. Annual total loss is an expression of the risk. The risk is distinguished from the hazard, which could be defined, in the case of this Study, as the overt danger to the road and road users.
Frequency of Road Closure Disasters per Year [FRCD]	:	The number of RCD occurrences per year for a slope (Nos. of RCD/year)
FRCDp	:	Potential FRCD
FRCDa	:	Actual FRCD
Intensity of Road Closure Disasters of a Road Section [IRCD]	:	Average RCD occurrences per km year for a road section, *i.e.* the total FRCD's for the road section divided by its length (Nos. of RCD/year/km)
IRCDp	:	Potential IRCD
IRCDa	:	Actual IRCD
Annual Loss due to RCD [AL]	:	Annual loss induced by RCD of a slope or a stream (Rs/year)
ALp	:	Potential AL
ALa	:	Actual AL
Intensity of Annual Loss of a Road Section [IAL]	:	Intensity of annual loss of per unit length per year (Rs/year/km)
IALp	:	Potential IAL
IALa	:	Actual IAL
Chainage	:	A point in the road represented by kilometer posts + displacement from the kilometer post in meters from starting point of a road section, as CH xx km + xxx m.

Acronyms/Abbreviations

AADT	Average Annual Daily Traffic
ACLoV	Average Cancellation Loss of Vehicles
ADB	Asian Development Bank
ADLoV	Average Detour Loss of Vehicles
ADPC	Asian Disaster Preparedness Center
ADRC	Asian Disaster Reduction Center
ALE	Average Life Expectancy at birth
ALp	Potential Annual Loss of a site
ANHD	Average Numbers of Human Deaths per RCD
ANVL	Average Numbers of Vehicles Loss per RCD
AR	Automatic Rain gauge
ARMP	Annual Road Maintenance Plan
ARR	Assistant Resident Representative
ASLoV	Average traffic Suspension Loss of Vehicles
ATP	Average Traffic Persons of a vehicle
AVS	Average Vehicle Speed
AWLoV	Average Waiting Loss of Vehicles
BCR	Benefit Cost Ratio
C	Cost
CARE	Cooperative for American Relief Everywhere (NGO)
CBS	Central Bureau of Statistics
CDMA	Code division multiple access
CDO	Chief District Officer
CEM	Coefficient of Effectiveness of Structural Measure Effectiveness for FRCDp
CH	Chainage
CP	Cancellation Percentage
C/P	Counterpart(s) or Counterpart Organization(s)
CPoWTP150	Cancellation percentage of Willingness to Pay equal to over than Rs 150
CPoWTP300	Cancellation percentage of Willingness to Pay equal to over than Rs 300
CPoWTP<150	Cancellation Percentage of Willingness to Pay under than Rs 150 instead of waiting
DAL	Decrease in Annual loss due to structural measure
DALy	Decrease in Annual Loss due to structural measure of y year
DDC	District Development Committee
DDO	District Development Office
DG	Director General
DDG	Deputy Director General

DEM	Digital Elevation Model
DF	Debris Flow
DFID	Department for International Development
DF/R	Draft Final Report
DHM	Department of Hydrology and Meteorology
DP	Detour Percentage
DPdNH	Detour Percentage divert to Naubise or Hetauda
DPdPB	Detour Percentage divert to Pokhara or Butawal
DPO	District Police Office
DMG	Department of Mines and Geology, Ministry of Industry Commerce and Supplies
DMSPP	Disaster Mitigation Support Program Project
DoLIDAR	Department of Local Infrastructure Development and Agriculture Road, Ministry of Local Development
DOR	Department of Roads
DOS	Department of Survey
DPTC	Disaster Prevention Training Center
DR	Discount Rate
DRO	District Road Office
DTM	Department of Transport Management
DWIDP	Department of Water Induced Disaster Prevention
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
ENPV	Economic Net Present Value
E/R	Evaluation Report
EU	European Union
FCR	Fixed Cost for Reopening of a RCD
F/R	Final Report
FRCD	Frequency of Road Closure Disaster of a site
FRCDa	Actual Frequency of Road Closure Disaster of a site
FRCDabm	Actual Frequency of RCD of a site before structural measure is installed
FRCDp	Potential Frequency of Road Closure Disaster of a site
FRCDpom	Potential Frequency of Road Closure Disaster of a site without structural measure
FRCDpwm	Potential Frequency of Road Closure Disaster with structural measure
FS	Frequency Score for FRCDp
F/S	Feasibility Study
FTP	File Thrasher Protocol
GDP	Gross Domestic Product
GIS	Geographic Information System

GON	Government of Nepal
GPS	Global Positioning System
GTZ	Technical Cooperation of the Federal Republic of Germany
GWHa	Actual Gross Working Hours
HLLp	Potential Value of Human Lives Loss of a RCD
IALp	Potential Intensity of Annual Loss of a section
INGO	International Non-Governmental Organization
IC/R	Inception Report
ICIMOD	Integrated Centre for Integrated Mountain Development
IEE	Initial Environmental Evaluation
IRCD	Intensity of Road Closure Disaster
IRCDp	Potential Intensity of Road Closure Disaster of a section
IRCS	International Red Cross Society
IT/R	Interim Report
JICA	Japan International Cooperation Agency
LF	Lobar Force
Lp	Potential Loss of a RCD
LRCpoF	Potential Length of Road Closure section of Full width of a RCD
LRCpoP	Potential Length of Road Closure section of Partial width of a RCD
LS	Length of Section
LTSp	Potential Losses of Traffic Suspension of a RCD
LWS	Lutheran World Services
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MFT	Main Frontal Thrust
M/M	Minutes of Meeting
M-N	Mugling-Narayangharh
MNWIDPP	Mugling-Narayangharh Water Induced Disaster Prevention Project
MOEST	Ministry of Environment Science and Technology
MOFSC	Ministry of Forests and Soil Conservation
MOHA	Ministry of Home Affairs
MOIC	Ministry of Information and Communication
MOLD	Ministry of Local Development
MOLT	Ministry of Labour and Transport Management
MOPPW	Ministry of Physical Planning and Works
MOWR	Ministry of Water Recourses
M/P	Master Plan
MSL	Mean Sea Level
NAR	Non Automatic Rain Gauge

NCDp	Numbers of Predicted Closure Days of the whole width of the road on the survey site per RCD
NCDpV	Numbers of predicted Closure Days of a Vehicle
NCHpV	Numbers of predicted Closure Hours of a Vehicle
NDRA	The Natural Disaster Relief Act
NEA	Nepal Electric Authority
NGIIP	National Geographic Information Infrastructure Program
NGO	Non Government Organization
NK	Nippon Koei Co., Ltd.
N-M	Narayangharh-Mugling
Nos.	Numbers
NORAD	Norwegian Agency for Development Cooperation
NPC	National Planning Commission
NPO	Nonprofit Organization
NWP	Non-Waiting Percentage
O-D	Origin – Destination
PDM	Project Design Matrix
PIP	Priority Investment Plan
PM	Project Manager
PMED	Planning Monitoring and Evaluation Division
POP	Population
PP	Pilot Project(s)
PPD	Policy and Planning Division
PR/R	Progress Report
PVC	Poly-Vinyl Chloride
Q/N	Questionnaire
RCD	Road Closure Disaster
RCDp	Potential Road Closure Disaster
RCp	Potential Reopening Cost of a RCD
RF	Rock Fall
RRN	Rural Reconstruction Nepal, NGO
RRR	Risk Reduction Ratio
Rs	(Nepalese) Rupee
RSL	Road Section Length
S/C	Steering Committee
SCF	Save the Children Found
SDC	Swiss Development Corporation
SF	Slope Failure
SL	Slide or Landslide

SPM	Suspended Particulate Matter
SRN	Strategic Road Network
S/W	Scope of Work
TA	Technical Assistance
TCR	Travel Conversion Ratio
The Study	The Study on the Disaster Risk Management for Narayangharh – Mugling Highway
The Team	The JICA Study Team
TOR	Terms of Reference
TSDC	Transport Sector Development Project
UCLp	Unit Potential Losses due to Cancellation of trip per vehicle per RCD
UDL	Unit Detour Loss
UDLdNH	Unit Detour Loss of a Vehicle when divert to Naubise or Hetauda
UDLdPB	Unit Detour Loss of a Vehicle when divert to Pokhara or Butawal
UHL	Unit Value of Human Lives Loss
ULTS	Unit Loss of Traffic Suspension of a vehicle
UMN	United Mission to Nepal
UNDP	United Nations Development Program
URCpMoF	Unit Reopening Cost per one mater length of Full width road closure
URCpMoP	Unit Reopening Cost per one mater length of Partial width road closure
U.S.	United State of America
USAIDM-N	United States Agency for International Development Mission to Nepal
UVOC	Unit Vehicle Operation Cost per km per vehicle
UVL	Unit Value of Vehicle Loss
UVTT	Unit Value of Traffic Time of a vehicle
UWL	Unit Waiting Loss of a vehicle
VDC	Village Development Committee
VLp	Potential value of Vehicle Loss of a RCD
VOC	Vehicle Operation Cost
WB	World Bank
WFP	World Food Programme
W/G	Working Group (comprising of the C/P)
WH	Waiting Hours
WP	Waiting Percentage
W/S	Workshop
WTP	Willingness To Pay
y	Year from countermeasure installation

Measurement Units

Area

cm^2 = Square-centimeters (1.0 cm x 1.0 cm)
m^2 = Square-meters (1.0 m x 1.0 m)
km^2 = Square-kilometers (1.0 km x 1.0 km)
ha = Hectares (10,000 m^2)

Volume

cm^3 = Cubic-centimeters (1.0 cm x 1.0 cm x 1.0 cm or 1.0 milliliter)
m^3 = Cubic-meters (1.0 m x 1.0 m x 1.0 m or 1.0 kiloliter)
L = Liter (1,000 cm^3)
mL = milliliter (1/1,000 L)

Length

mm = Millimeters
cm = Centimeters (cm = 10 mm)
m = Meters (m = 100 cm)
km = Kilometers (Km = 1,000 m)

Weight

g = Grams
kg = Kilograms (1,000 g)
ton = Metric tone (1,000 kg)

Currency

Rs = Nepalese rupee

Time

s = Second
min = Minutes (60 s)
hr = Hours (60 min)

THE STUDY
ON
DISASTER MANAGEMENT
FOR
NARAYANGHARH –MUGULING HIGHWAY

FINAL REPORT
Volume III: DATA AND DRAWING

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MINUTES AND PARTICIPANTS MEETING/

SEMINAR/WORKSHOP

1. Participants List and Minutes of Meeting (M/M) of 1st Steering Committee Meeting

1st Steering Committee Meeting
Study on Disaster Risk Management for Narayangharh-Mugling Highway

Venue: Secretary's Office, Ministry of Water Resources

Date: 9 August 2007, 11:30 am

No.	Name	Designation	Organization
1	Ramesh Raj Bista	DDG	DoR
2	Narayan Prasad Bhattarai	DG	DWIDP
3	Jitendra Ghimire	Secretary	MORW
4	Nogendra Sapkota	Social Environment Office	ADB
5	Shiv Chandra Jha	DMD	NEA
6	Ramesh Tuladhar	Team Leader/Nepal	DWIDP
7	Yasuke Tsumori	ARR	JICA Nepal Office
8	Kenta Ono	Office In-charge	JICA Head Office
9	Hitoshi Kato	Disaster Prevention Advisor	JICA Expert, DWIDP
10	Masatoshi Eto	Team Leader	JICA Study Team
11	Kenichi Tanaka	Geology	JICA Study Team
12	Minihiro Mori	Road Disaster Management	JICA Study Team
13	Satoru Noda	Project Coordinator	JICA Study Team
14	Takeshi Kuwano	Env/Social Consideration	JICA Study Team
15	Kahadananda Lamsal	Hydrologist	JICA Study Team

Minutes of the First Steering Committee Meeting
Of
The Study on Disaster Risk Management for Narayangharh-Mugling Highway

Agreed upon between

Department of Water Induced Disaster Prevention, Ministry of Water Resources,
Department of Roads, Ministry of Physical Planning and Works,
and
Japan International Cooperation Agency

JICA Study Team

Date: 9 August 2007, 11:30 AM

Venue: Secretary's Office, Ministry of Water Resources

Chairperson: Mr. Jitendra Ghimire, Officiating Secretary, MOWR

Presentations:

P-1 Dr. Ramesh Tuladhar (Counterpart Team Leader): He gave welcome speech and introduction the JICA Study Team on Disaster Risk Management for Narayangharh-Mulging highway to the members of the steering committee.

P-2 Narayan P. Bhattarai (DG, DWIDP): He highlighted on the necessity of the JICA study for the disaster risk management on Narayangharh-Mulging Highway. Scope of Works and its Minutes of Meeting were signed on January 31, 2007 for the study on key section of national highway to enter into the capital Kathmandu from Terai part of the nation. JICA and World Bank assisted on rehabilitation of damaged highway by July 31, 2003 incessant rainfall. DWIDP has requested JICA for the study of the damaged highway to assist in providing suggestions and recommendations for improvement of the highway in a long term basis.

P-3 Ramesh R. Bista (DDG, DOR): He explained about activities-DOR has just completed sector-wise road improvement project to develop road network in the country. The aim of the project was to make road network accessible for people living in hilly area (up to 4-hour walking distance) and Terai area (up to 2-4 hour walking distance). Though road network has been expanded greatly in the country but vehicles cannot ply all the year round over a large sections of road network. Safety and traffic conditions improvement on the highway is the major concern of the DOR. Narayangharh-Mugling highway is ~~an~~ intermediate type in terms of road width highway which was completely washed away on July 31, 2003 by heavy rainfall. The restored highway is still vulnerable to landslides. This section of road is life line of national highway. The blockade of this highway will cut off the capital Kathamandu from Terai parts of the country.

P-4 Masatoshi Eto (Team Leader, JICA Study Team): He appreciated and extended his sincere thanks to all participants of the meeting. He presented outline and objectives of the

study; and discussed on the preparation of hazard map and formulation of basic strategy for risk management. He mentioned that implementing organizations are DWIDP and DOR, therefore, requested for their support and help to accomplish the study successfully. He also mentioned that he prepared Guidelines to Road Slope Protection Works in 2003 with the help of DOR engineers. The partnership between this study and Sindhuli Road Project was emphasized. Economic, social and environmental aspects will be taken into consideration while making recommendations for the improvement of the highway. Basic strategy for road disaster management will be developed by the end of October. The feasibility study will be carried out during January-February 2008. Some pilot projects will be taken into considerations after October.

P-5 Kenichi Tanaka (Geologist, JICA Study Team): He presented on hazard mapping and classifications of slope hazards. He mentioned that GIS database and satellite images will be used for hazard mapping. At present, most of the potential landslide sites are not active only some of them are active. He discussed on mapping inventory survey and topographic/ geologic survey; and also discussed on pipe strain meter to find out landslide prone areas. He has shown some photographs of cracked retaining walls along the highway due to pushing of landslides.

P-6 Mikihiro Mori (Road Disaster Management Expert, JICA Study Team): He presented on methods of: risk analysis, estimation of disaster frequency, and estimation of disaster magnitude. He discussed on the monetary risk estimation of a slope, and cost and benefit analysis by structural measurements. Similarly, selection policy for preventive measures: and anticipated road disasters and their solutions were also presented. The selection of the pilot project sites was also discussed.

P-7 Nogendra Sapkota (ADB-Nepal Representative): ADB has assisted a lot in road network development. However, a considerable road network will be damaged every year during monsoon months. ADB is ready to help in road improvement aspects for the full fledge operation of the major road networks in the country all the year round.

P-8 Shiv Chandra Jha (DMD, NEA): Kulekhani-I and Mid-Marsyangdi hydropower projects were very much affected by the floods. Marsyangdi hydropower project is on the Prithivi (Kathmandu-Pokhara) highway, any kind of disturbances or disaster on the project will block the highway. Because of 2003 flood it took a long time to restore the Prithivi highway as well as power supply from the Marsyangdi hydropower project was also disrupted for a long time. NEA is aware on importance of accessibility of roads or highways to hydropower projects, therefore, NEA is paying importance on access roads constructions to hydropower project sites.

Discussions:

D-1 **Ramesh R. Bista** (DDG, DOR): He said that DOR is ready to work together for the safety of the road networks in future. He asked about the number of pilot projects to be carried out by the JICA Study Team.

2/3

A-1 **Masatoshi Eto** (Team Leader, JICA Study Team): The number of pilot projects will be decided after the reconnaissance survey scheduled for next week. The long stretch of the highway having severe landslide problems will be selected for the pilot projects. There could be 2-3 pilot project sites along the highway. Pilot project sites and plan will be finalized by the end of October.

D-2 **Narayan P. Bhattarai** (DG, DWIDP): He suggested that pilot project sites should be selected based on Debris flow and landslides.

A-2 **Kenichi Tanaka** (Geologist, JICA Study Team): Debris flow is most serious problem along the Narayanghat-Mugling highway. Agricultural activities of people is also including landslides along the highway, therefore, people living along the highway side should be educated on the landslides protection works.

D-3 **Narayan P. Bhattarai** (DG, DWIDP): He discussed on the strategy for the road disaster management on the highway.

A-3 **Mikihiro Mori** (Road Disaster Management Expert, JICA Study Team): He suggested that local people living along the highway and local bus drivers should cooperate on informing to local DOR office about the condition of the highway. It will help to take timely action by the DOR to avert the road disasters.

Decision of the meeting:

The steering committee has appreciated objectives, outline, and methodologies of the study. The committee has suggested the JICA Study Team to consider the suggestions made in the discussion session while implementing the project.

Closing of the meeting:

Jitendra Ghimire (Secretary, MOWR): Honorable secretary termed the presentation made by the JICA Study Team as an interesting and comprehensive one; and appreciated the presentation. He also appreciated issues raised during discussion session. The Narayangharh-Mugling section of national highway is the most important for the nation. MOWR provides all kind of supports and necessary help for the JICA Study Team on Disaster Risk Management on the highway to accomplish the study successfully.

Mr. Narayan P. Bhattarai Director General, Department of Water Induced Disaster Prevention, Ministry of Water Resources	Mr. Ramesh R. Bista DDG, Department of Roads, Ministry of Physical Planning and Works	Mr. Masatoshi Eto Team Leader JICA Study Team

Director General Deputy Director General

1st Steering Committee Meeting

The Study on Disaster Risk Management for Narayangharh-Mugling Highway

Date: 9 August, 2007, 11:30 am

Venue: Secretary's Office, Ministry of Water Resources

Chairperson: Mr. Jitendra Ghimire, Secretary, MoWR

Members:

1. Mr. Narayan Prasad Bhattarai, DG, DWIDP
2. Mr. Ramesh R. Bista, DDG, DoR
3. Mr. Shiva Chandra Jha , Nepal Electricity Authority
4. Mr. Yusuke Tumori, JICA Nepal Office

   Mr. Kenta Ono, JICA Headquorters
5. Mr. Nogendra Sapkota, Representative, ADB
6. Mr. Hitoshi Kato, JICA Advisor, DWIDP
7. **The Study Team:**

   Mr. Masatoshi Eto, Team Leader (Japan)

   Mr. Mikihiro Mori

   Mr. Kenichi Tanaka

   Mr. Takeshi Kuwano

   Mr. Khadananda Lamsal

   Mr. Satoru Noda

   Dr. Ramesh Tuladhar, Team Leader (Nepal)

Counterpart Members List

S. No.	Name	Position	Organization
1	Dr. Ramesh Tuladhar	Team Leader	DWIDP
2	Mr. Shree Kamal Dwivedi	Engg. Geologist	DWIDP

Agenda:

1. Necessity of the Study from Mr. Narayan P. Bhattarai, DG, DWIDP: **5 minutes**
2. Information sharing regarding overall road plan and importance of protection of Narayanghat to Mugling road by Mr. Ramesh R. Bista, DDG, DoR : **5 minutes**
3. Infromation sharing on activities of Marsyangdi Hydropower House by Representative of NEA: **5 minutes**
4. Power Point Presentation by the Study Team: **30 minutes**
5. Discussion(s) and decision(s)

2. Participants List of 1st Technical Working Group Meeting

1st Technical Working Group Meeting

Study on Disaster Risk Management for Narayangharh-Mugling Highway

Venue: Meeting room, DWIDP

Date: 10 August 2007

No.	Name	Designation	Organization
1	Narayan Pd. Bhattarai	DG	DWIDP
2	Ramesh Tuladhar	Geologist	DWIDP
3	Binod Pd. Sapkota	Engineer	DoR
4	S. K. Hyuju	SDE	DWIDP
5	Samanta Man Sthapit	SDE	DWIDP
6	Rajan Man Shreatha	Mechanical Engineer	DWIDP
7	Sanjaya Pradhan	Engineer	DWIDP
8	Govinda Paudel	Engineer	DWIDP
9	Rajan Shakya	Sociologist	DWIDP
10	Khail Nath Dahal	Engineer, Geologist	DWIDP
11	Shanmukhesh C. Amatya	SDHG	DWIDP
12	Saroj Pandit	SDE	DWIDP
13	K. R. Dahal	DDG	DWIDP
14	Prakash Man Shrestha	Engineer	DWIDP
15	Yam Bahadur Shah	Engineer	DWIDP
16	Pradip Shah	Engineer	DWIDP
17	Narahari Kharel	S.M.	DWIDP
18	Rishav Risal	S. Engineer	DWIDP
19	Kamal Kumar Shrestha	S. Engineer	DWIDP
20	Rajendra Sharma	Hydrologist	DWIDP
21	Shree Kamal Dwivedi	Engineer Geologist	DWIDP
22	Masatoshi Eto	Team Leader	JICA Study Team
23	Kenichi Tanaka	Geology	JICA Study Team
24	Takeshi Kuwano	Environmental/Social Consideration	JICA Study Team
25	Satoru Noda	Project Coordinator	JICA Study Team
26	Khadananda Lamsal	Hydrologist	JICA Study Team

3. Agenda and Participants List of Seminar/Workshop in Bharatpur

Agenda of Seminar/Workshop in Bharatpur

Of

The Study on Disaster Risk Management for Narayangharh- Mugling Highway

1. Date/Time: 2007.9.13 (Thurseday) 13:00- 16:30
2. Place: Seminar Hall of Hotel Global, Bharatpur
3. Agenda:
   1) Introduction: 13:00 -13:05
      by Dr. Ramesh TULADHAR ; Chief of Sabo Section, DWIDP

   2) Sediment Related Disasters in Nepal: Challenge and Issues ; 13:05 -13:30
      by Dr. Ramesh TULADHAR ; Chief of Sabo Section, DWIDP

   3) Outline of The Study; 13:30 -13:50
      By Mr. Masatoshi ETO; Team Leader of the Study Team
   - Question & Answer: 13:50 – 14:00

   4) Disaster Types and Critical Slopes and Kholas along the Highway; 14:00 -14:20
      By Mr.Takashi SUGIMOTO; Co-Team Leader of The Study Team
   - Question & Answer: 14:20 – 14:30

   ― Tea Break ― 14:30- 14:50

   5) Rainfall in Past Disasters and Criteria of Early Warning; 14:50 15:20
      By DR. Khadananda LAMSAL
   - Question & Answer: 15:20 – 15:30

   6) Proposed Pilot Project of Disaster Mitigation by Stakeholder Partnership
      15:30- 15:50 By Mr. Masatoshi ETO; Team Leader of the Study Team

   - Question & Answer/Discussion: 15:50 -16:20

   7) Closing Remark: by Dr. Ramesh TULADHAR 16:20-16:30

Participants of 1st Seminar/Workshop
Study on Disaster Risk Management for Narayangharh-Mugling Highway

Venue: Seminar Hall of Hotel Global, Narayangharh
Date: 13 September 2007

No.	Name	Designation	Organization
1	Ramesh Tuladhar	Team Leader/Nepal	DWIDP
2	Saroj Pandit	Project Manager	MNWIDPP
3	Yogendra Mishara	Engineer	MNWIDPP
4	Shree Kamal Dwivedi	Engineer Geologist	DWIDP
5	Ratna Bahadur Malla	VDC Chief	Dharechok VDC
6	Basanta Raj Paudel	Engineer	MNWIDPP
7	Krishna Raj Pathak	Engineer	MNWIDPP
8	Lok Nath Bhandari	VDC Chief	Chandi Bhanjyang
9	Bad Prasad Bajgain	VDC Chief	Dhakhani
10	Ajaya Paudel	VDC Chief	Kabilash VDC
11	Saraswoti Adhikari	Village Teacher	Kabilash VDC
12	Bal Ram Luitel	DDC Chairman	Citwan DDC
13	Prakash Regmi	Project Advisor	NGO Coordinator Committee
14	Deepak Rana	Police Officer	DPO, Bharatpur
15	Hitoshi KATO	JICA Expert	DWIDP
16	Masatoshi ETO	Team Leader	JICA Study Team
17	Takashi SUGIMOTO	Co Team Leader	JICA Study Team
18	Khadananda Lamsal	Hydrologist	JICA Study Team
19	Satoru NODA	Project Coordinator	JICA Study Team
20	Madhu Bhattarai	Socio-economist	JICA Study Team
21	Sujan Adhikari	Geologist	JICA Study Team

4. Participants List and Minutes of Meeting (M/M) of Meeting on the Progress Report

Meeting on the Progress Report
Study on Disaster Risk Management for Narayangharh-Mugling Highway

Venue: Seminar Hall of DWIDP
Date: 4 November 2007, 14:00 PM

No.	Name	Designation	Organization
1	Narayan Prasad Bhattarai	DG	DWIDP
2	Ram Prasad Pathak	Senior Divisional Engineer	DOR
3	Bed Kantha Yogol	Senior Divisional Engineer	DOR
4	Shiva Chandra Jha	DMD	NEA
5	Ramesh Man Tuladhar	Team Leader/Nepal	DWIDP
6	Sharmukhesh C. Amatya	Senior Divisional Hydrologist	DWIDP
7	S. K. Hyoju	SDE	DWIDP
8	Basanta Raj Paudel	Engineer	MNWIDPP
9	Krishna Raj Pathak	Engineer	MNWIDPP
10	Gobinda Paudel	Engineer	DWIDP
11	Rajendra Sharma	Hydrologist	DWIDP
12	Khila Nath Dahal	Engg. Geologist	DWIDP
13	Kishor Kumar Karki	Soil Conservation Assistant	DWIDP
14	Pradip Sah	Engineer	DWIDP
15	Manju Sharma	Sociologist	DWIDP
16	Sangita Singh	Sociologist	DWIDP
17	Bharat Mani Dhital	Senior Divisional Engineer	DWIDP
18	Basistha Raj Adhikari	Senior Divisional Engineer	DWIDP
19	N. M. Joshi	Senior Divisional Engineer	DWIDP
20	Yusuke TSUMORI	ARR	JICA Nepal Office
21	Saurab Rana	Program Officer	JICA Nepal Office
22	Hitoshi KATO	JICA Expert	DWIDP
23	Takashi SUGIMOTO	Co-team leader	JICA Study Team
24	Kenichi TANAKA	Geology	JICA Study Team
25	Hiroyuki ONO	Social/Economy	JICA Study Team
26	Takeshi KUWANO	Environmental/Social Consideration	JICA Study Team
27	Sujan Raj Adhikari	Geologist	JICA Study Team

Summary of The Meeting on The Progress Report
Of
The Study on Disaster Risk Management for Narayangharh-Mugling Highway

Agreed upon between

Department of Water Induced Disaster Prevention, Ministry of Water Resources,
Department of Roads, Ministry of Physical Planning and Works,
and
Japan International Cooperation Agency

JICA Study Team

Date: November 4th 2007, 14:00 to 16:00

Venue: DWIDP Seminar Hall

Chairperson: Mr. N.P. Bhattarai, DG, DWIDP

Presentations:

P-1 Dr. Tuladhar (Counterpart Team Leader, DWIDP): He gave a welcome speech and introduced the overall program of the meeting.

P-2 Mr. Sugimoto (Co-Team Leader, JICA Study Team): He esteemed and bestowed his sincere thanks to all the participants of the meeting. He presented progress of the study that included Inventory Survey, Hydrological Survey and Geological/ Topographical Survey. And also he informed that Basic Strategy is in planning process. Besides, he also summarized the rainfall analysis and the post 2003 disaster countermeasures by M-N WIDP which had considerable positive effects.

P-3 Dr. Ono (Social/Economy, JICA Study Team): He presented results of Inventory Survey that included 305 slope sites. In this study, the potential frequency of RCD and potential annual loss were mainly estimated. He briefly described how to carry out the Inventory Survey, and also talk introduced parameters of FRCDp and ALp and the result. He also introduced 12 major high risk sites in NM Highway and recommended preventive countermeasures.

P-4 Mr. Tanaka (Geologist, JICA Study Team): He presented the current geological condition of NM Highway. In his presentation, detail results of geological and topographical survey conducted in four major sites were well elucidated. He also showed some photographs of visible deformation in retaining walls along the highway due to pushing of landslides which also highlighted the current situation of the highway.

P-5 Mr. Sugimoto (Co-Team Leader, JICA Study Team): He presented on Basic Strategy and policy of the study. In his presentation, he highlighted the value of FRCDp and ALp. And he also emphasized that steady of road blockade regular maintenance, of check dam function, quick response and reopening, traffic early information system and disaster

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mitigation activities should be continuously implemented to decrease the ALp. He said that structural countermeasures for the feasibility study were set out as Level I and Level II. He also recommended the structural countermeasures with approximate cost estimate for selected major sites. He stressed that there should be regular maintenance of road which should be carried out by DoR and Sabo Dam should be carried out by DWIDP. And also he showed the approximate estimated cost for the maintenance of Sabo Dam. Furthermore he also mentioned about the risk level of Ruwa Khola and additional countermeasure to mitigate the problem faced by power plant and the road.

P-6 Dr. Kuwano (Environmental/social consideration, JICA Study Team): He presented the outline of the very next stage of the study. In his presentation, he highlighted that the main activities in Phase II and III would be a feasibility study, a pilot project and detail technical advice for each component of every activities. He also presented schedule of pilot project along with the reason to choose Kabilas Village for a pilot project.

Discussions:

D-1 **Shiv Chandra Jha** (DMD, NEA): He basically discussed on the social and environmental act and suggested the team to put Ruwa Khola site in Phase II for detail survey.

A-1 **Dr. Kuwano** (Environmental/social consideration, JICA Study Team): He said that there was JICA guideline for Social and Environmental Act which would be exercised on upcoming phases.

A-2 **Dr. Tuladhar and Mr. Adhikari** (Counterpart Team Leader, DWIDP, Geologist/Site Engineer, JICA Study Team): They focused on the poor socioeconomic situation of the villagers along the highway. They said villagers were cutting the tree not only for domestic use but also for sustaining their livelihood. So implementation part of the Act would be hard even though we could motivate the villagers for the environmental protection, and protection of the highway.

A-3 **Mr. Tanaka** (Geologist, JICA Study Team): He said, in the case of the Ruwa Khola, we might include it in second phase but with reduction in countermeasure. But we still have to decide afterwards following discussions.

Q-2 **Mr. N.M Joshi** (SDE, DWIDP): How helpful was the satellite image for identifying the disaster zone?

A-1 **Mr. Tanaka** (Geologist, JICA Study Team): They were quite useful to identify failure zone. Due to the Image enhancement and visualization technique, they could easily distinguish the disaster prone area but there must be ground verification too.

Q-3 **Mr. B. K. Yogol** (SDE, DOR): As presented in the presentation, how the counter measures Level I and Level II would help to mitigate the mass movement if the whole mass is moving?

A-1 **Mr. Tanaka** (Geologist, JICA Study Team): He told that here the whole mass was moving very slowly so countermeasures of Level I and Level II would be useful to some extent but if the mass was moving rapidly then this would be a different story. For the case of the removal of the deposits of Sabo Dam, it is urgently required because of the fragile geological condition and the slide in between the big landslide is still in active condition which will definitely reduce the function of the Sabo dam as it is already filled up with the deposits.

D-4 **Mr. S. C Amatya** (SDE, DWIDP): Why we can't make series of Check dam from the top of the slide rather than removing the deposits of the debris every year?

A-1 **Mr. Tanaka** (Geologist, JICA Study Team): The main function of the Sabo Dam is to catch the maximum amount of debris deposits, as NM Highway lies in the fragile geology condition, and sediment generated is too high over here so debris should be removed every year for the effectiveness of Sabo Dam. And the area is also not enough in the top part of the slide to catch the debris. So series of Sabo Dam are constructed in the lower part where they can catch maximum amount of debris deposits.

Decision of the meeting:

The participants had appreciated the efforts of study team. They also suggested the JICA Study Team to consider the suggestions made in the Question and Answer/Discussion Session while implementing the Second phase of project.

Closing of the meeting:

Narayan P. Bhattarai (DG, DWIDP): He gave vote of thanks to the Study Team for finishing the First phase of the study. He cherished the issues raised during Question and Answer/Discussion Session on the Progress Report submitted by the JICA Study Team. And he wished the Study Team for the success of the study.

Mr. Narayan P. Bhattarai Director General, Department of Water Induced Disaster Prevention, Ministry of Water Resources	Mr. Ramesh R. Bista DDG, Department of Roads, Ministry of Physical Planning and Works	Mr. Takashi Sugimoto Co-Team Leader JICA Study Team

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5. Minutes of Understanding for Regular Operation and Maintenance for N-M Highway Early Information System and Water-induced Desaster Managemnet System for Kabilash Village

Minutes of Understanding

for

Regular Operation and Maintenance for
Narayangharh- Mugling (N-M) Highway Early Information System and;
Water-induced Disaster Management System for Kabilash Village

Among
Planning and Special Service Division, Ministry of Home Affairs,
Department of Water Induced Disaster Prevention, Ministry of Water Resource,
Department of Road, Ministry of Physical Planning and Works, and
Department of Local Infrastructure, Development and Agriculture Road, Ministry of Local Development.

Katmandu, 24 June 2008

Government of Nepal
Ministry of Home Affairs

Mr. Pratap Kumar Pathak

Joint Secretary
Planning & Special Service Division,
Ministry of Home Affairs

Mr. Narayan Prasad Bhattarai

Director General
Department of Water Induced Disaster Prevention,
Ministry of water Resources

Mr. Tulasi Prasad Sitaula

Director General
Department of Road,
Ministry of Physical Planning and Works

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads
Babar Mahal

Mr. Dhana Bahadur Tamang

Director General
Department of Local Infrastructure Development and Agriculture Road,
Ministry of Local Development

Mr. Masatoshi ETO

Team Leader
Study Team on the Disaster Risk Management for Narayangharh – Mugling Highway,
Japan International Cooperation Agency

Intent of Two Systems

Intent of Two Systems

The Narayangharh -Mugling Highway (hereinafter referred to as "the N-M Highway") is one of the most important road sections in Nepal. And this section is the most slope disaster prone national road section in Nepal. Kabilash village is the most disaster-prone village along the highway. A large number of landslides occurred on 30th July, 2003 and caused a heavy damage to the road section due to the water-induced disasters killing eleven people due in Kabilash Village.

Following two systems by pubic/private cooperation are important for effective and efficient disaster risk management.
- The N- M highway early information system and;
- Water induced disaster management system for Kabilash Village

Understanding of Operation and Maintenance of Two Systems

The above mentioned two systems have been lunched as pilot projects from June 2008 by 'Japan International Cooperation Agency Study Team on Disaster Risk Management for Narayangharh-Mugling Highway (hereinafter referred to as "JICA Study Team")', counterpart team (DWIDP, DOR) and newly formulated committee for planning & management (district level, Chitwan District) of the pilot projects.
The systems will be evaluated and modified in second half of November 2008, and the modified systems will be conducted continuously by the Republic of Nepal.

Outline of the N-M Highway Early Information System

Outline of the system is shown in Figure 1.
Early information system includes road traffic obstacles such as accident, strike, road slope disaster, and warning for slippery/hazardous condition due to heavy rain. Information on the condition of road blockage obstacle will be surveyed by patroller of District Police Office (hereinafter referred to as "DPO"), patroller/road supervisor/length worker of Division Road Office (hereinafter referred to as "DRO"), inhabitants, and drivers.
Rainfall data will be collected and computed into '12 hour half-value rainfall amount[1]' by DRO, Bharatpur and Kabilash Village development committee(hereinafter referred to as "Kabilash VDC"), which will be supervised by DWIDP.
Road early information will be disseminated to inform media, hotels in Bharatpur and Mugling by DPO posting notice into two notice boards at Anptari(Chainage 1 km) and Mugling(Chainage 36 km), and internet web-page (http://nmroad.gov.np).

The JICA Study Team, DWIDP and DOR, design the early information system, prepare equipments and computer applications, and train the persons responsible for the operation of systems, including rainfall monitoring and computer operation in June 2008.

[1] Rainfall amount by summing up of past hourly rainfalls, which are reduce half by every 12 hours.

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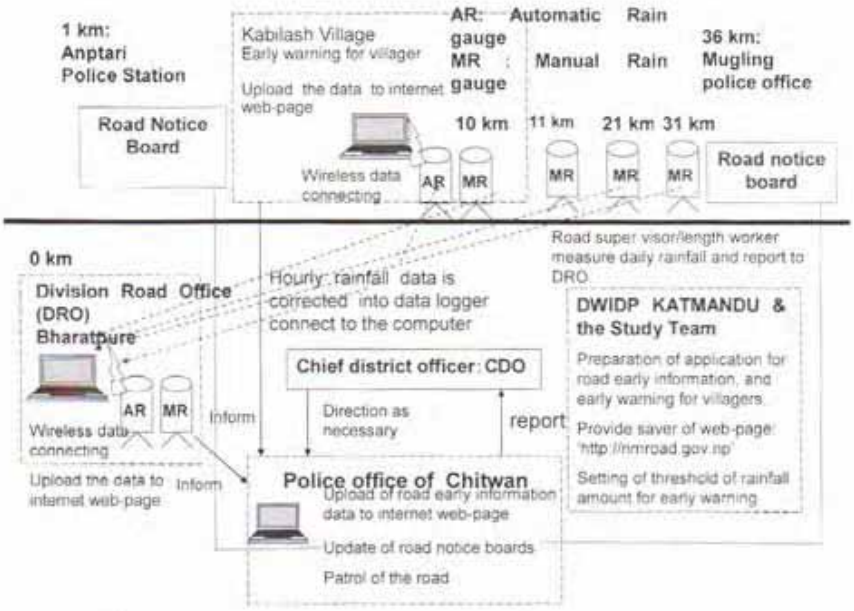


Figure 1 Schematic Chart of the N-M highway Early Information System

Outline of the Water Induced Disaster Management for Kabilash Village

The disaster management includes the following five items:

- Early warning/evacuation systems for water-induced disasters under heavy rain
- Hazard mapping
- Disaster education
- Simple structural measure on crossing stream at chainage 11km +500 of N-M Highway
- Forest plantation planning

The JICA Study Team together with DWIDP designs the early warning/evacuation system, prepares equipments and computer applications, and trains the persons responsible for the operation of systems, including rainfall monitoring and computer operation in June 2008.

The JICA Study Team subcontracted with Rural Reconstruction Nepal (RRN), a NGO, for facilitation on the pilot project of water-induced disaster management for Kabilash Village. RRN will appoint facilitator/ trainer/ lecturer, and instructor for simple structural measures. RRN would procure construction materials and hacks such as shovels.

Committee Formulation

For efficient disaster management, partnership of stakeholders (DPO, DRO, Mugling-Narayangharh Water Induced Disaster Prevention Project office (hereinafter referred to as MNWIDPP) and or division No.3 DWIDP office, communities, road users, information mediums) are required because of their important role. Therefore the committees, which treat

comprehensively the disaster management for road and communities, should be formulated. And the road early information system treats not only disaster information, but also other road traffic obstacles such as traffic accident for more effective loss reduction for road users.

There are two committees: 1. Planning & Management (district level) and 2. Advisory Committee (central level). The objectives of these committees are for planning and management (district level) and advisory committee (central level) are to plan/conduct/evaluate pilot projects and to offer useful advice respectively.

Both of central/district level organizations are required to operate these systems successfully though the pilot projects are operated in limited area. Because;

- These systems can also be applied to the area that has similar issues on water-induced disaster management.
- Cooperation of public/private sector is indispensable for sustainable and efficient disaster risk management.
- Both of administrative system and scientific technology are also indispensable to implement the activities successfully.

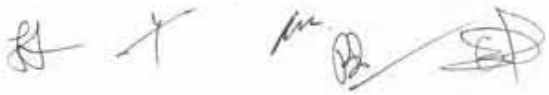
Call on Planning & Management Committee (District Level)

The pilot projects were commenced on June 2008 and will be completed in November 2008. The first planning & management committee meeting was held in Bharatpure, Chitwan District on 8 June 2008, chaired by assistant CDO of Chitwan District, and concept of the pilot projects systems were explained and accepted by officers concerned. The second committee meeting will be held under the chairpersonship of CDO, Chitwan District in mid November 2008 to evaluate and modify the systems implemented as pilot projects.

These systems should be modified and regularly implemented for the disaster prevention of the district. Therefore, after the completion of the pilot projects, Chitwan district disaster management preparedness committee already established under the chairpersonship of CDO and early warning system would carry out the activities as its agenda.

Call on Advisory Committee (Central Level)

Advisory committee meeting would be called by DWIDP in late November 2008 to provide technical advice to the planning and management committee. The advisory committee will also make understanding for financial support for the systems. Departments will select person in charge.



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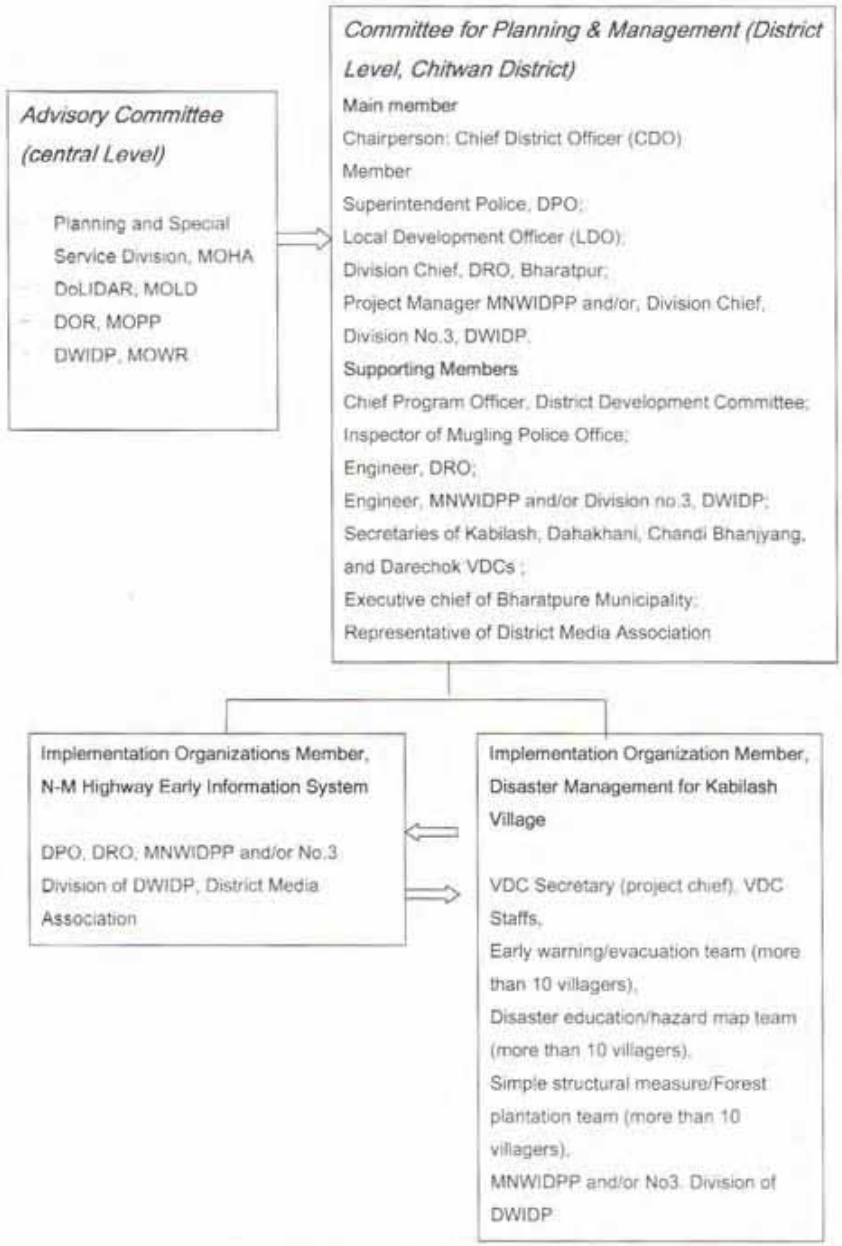

Figure 2 Committees and Implementation Organizations for the N-M Highway Early Information System and Water Induced Disaster Management for Kabilash Village

Table 1 Committee Members for the Pilot Projects

Committee for Planning & Management (District Level)

Organization	Role for the committee and the pilot projects
Chairperson	
Chief District officer (CDO), Chitwan	Call and facilitate 'planning & managing committee' General management of pilot project.
Main Member	
Superintendent Police (SP) , District Police office(DPO), Chitwan	Supervise junior staffs of the district police office for collecting/disseminating information of N-M highway traffic obstacle, early warning for heavy rain
Local Development Officer (LDO)	Supervise village development committees along N-M Highways (Kabilash, Dahakhani, Chandi Bhanjyang, and Darechok), and Bharatpur Municipality to facilitate inhabitants who help conduct road traffic obstacle monitors/reporters to police office/stations. Support Kabilash VDC for their disaster management activities (early warning & evacuation system, hazard mapping & disaster education, simple slope protection work and forestation planning)
Division Chief, Divisional Road office (DRO)	Appoint/supervise team of rain gauge monitoring, patrol and traffic obstacle report, emergency action for water-induced disaster on N-M Highway.
Project Manager, Mugling - Narayangharh Water Induced Disaster Prevention Project (MNWIDPP). And/or Division Chief, Division No.3, DWIDP (DDWIDP)	Supervise staffs for the role of DWIDP for the pilot projects as follows; Support to Kabilash Village's disaster management activities technically such as rainfall monitoring, computer operating for rainfall data computation and up-loading to internet web-page. Analyze rain and disaster occurrence relation and modify rainfall threshold for N-M highway users and for Kabilash Village in the feature, in every five year.
Supporting Member	
Chief Program Officer, District Development Committee (DDC)	Support LDO
Inspector of Mugling Police Office	Supervise junior staffs of the Mugling police office for the correcting/disseminating information of N-M highway traffic obstacle, early warning for heavy rain.
Engineer, DRO	Support Division Chief, DRO
Engineer, MNWIDPP. And or Engineer, Division No.3, DWIDP	Support project manager of MNWIDPP and/or Division Chief, Division No.3 of DWIDP
Secretary of Kabilash VDC	Explain about the N-M highway early information system to inhabitants. Facilitate inhabitants as monitor/reporter to police office/station about road obstacle phenomena. Assign and supervise member of team of early warning& evacuation, disaster education & hazard mapping, and simple slope protection work & forestation.

Secretary of Dahakhani, Chandi Bhanjyang, Darechok VDC And Executive Chief of Bharatpur Municipality	Explain about road early information system of the N-M highway to inhabitants. Facilitate inhabitants as monitor/reporter to police office station about road obstacle phenomena.
Advisory Committee (Central Level)	
Planning and Special Service Division Ministry of Home Affairs	Advice for disaster management policy and methodology, especially early warning/ evacuation system.
Department of Water Induced Disaster Prevention Ministry of Water Resource (Chairperson of Advisory Committee)	Advice for following water-induce disaster management policy and methodology. - Rainfall monitoring and thresholds setting for early warning/evacuation systems - Hazard mapping, disaster education for Kabilash Village - Simple structural measure at Kabilash Village
Department of Road, Ministry of Physical Planning and Works	Advice of methodology of patrol/report and quick response against road traffic obstacles
Department of Local Infrastructure Development and Agriculture Road, Ministry of Local Development	Advice methodology for implementation of community-based disaster management.

Table 2 Implementation Organization Members for N-M Highway Road Early Information System

Organization	Role
DPO (Chief Organization)	1. Operate and manage the N-M Highway traffic early information system as chief organization of the system. 2. Patrol/Inspection/judgment about road traffic obstacles. 3. Disseminate information by internet web-page (http//nmroad.gov.np), notice boards, information medium. 4. Urgent response to road traffic obstacles. 5. Maintain following equipments which JICA will be provided for upload the N-M Highway traffic early information into the internet web-page (http//nmroad.gov.np); one computer with software, one USB, one CDMA phone. 6. Pay CDMA phone communication fee for uploading internet web-page.
Divisional Road office (DRO)	1. Monitoring of automatic rain gauge at DRO office as follows. Once a day and or '12 hour rainfall is over 60 mm (noticed by buzzer and or inform to mobile phone of responsible person)'; compute from hourly rainfall data into '12 hour half-value rainfall amount', upload '12 hour half-value rainfall amount /time-series graph of rainfall amount' into internet web-page (http//nmroad.gov.np). When '12 hour half-value rainfall amount' is over threshold of caution, or warning for N-M highway road users; inform to district police office. 2. Monitoring manual rain gauge at DRO office, 11km, 21km and 31 km along the N-M highway once a day for subservient data. 3. Report road traffic obstacles to police office/station by patroller.

	supervisors, and length workers. 4. Urgent response to the road slope disaster. 5. Inspection and recording of road slope disaster. 6. Maintain following equipments which JICA will be provided for rainfall monitoring, and data computation & upload 'the 12 hour half-value rainfall amount' into the internet web-page (http//nmroad.gov.np); one compute with software, one USB, one CDMA phone , one automatic rain gauge, three manual rain gauges. 7. Pay CDMA phone communication fee for uploading web-page.
Kabilash VDC	1. Monitoring of automatic rain gauge at Kabilash VDC (Chainage 10km of the N-M highway) as follows. Once a day and or '12 hour rainfall is over 60 mm (noticed by buzzer and or inform to mobile phone of responsible person)': compute from hourly rainfall data into '12 hour half-value rainfall amount', upload '12 hour half-value rainfall amount /hourly fracturing graph' into internet web-page (http//nmroad.gov.np). 2. Monitoring/recording manual rain gauge at Kabilash VDC (Chainage 10km of the N-M highway) once a day for subservient data. 3. Explain about the N-M highway early information system to inhabitants. Facilitate inhabitants as monitor/reporter to police offices/station about road obstacle phenomena. 4. Maintain following equipments which JICA will be provided for rainfall monitoring one compute with software, one USB, one CDMA phone , one automatic rain gauge, one manual rain gauge. (DWIDP support technically and seek financial support) 5. Pay CDMA phone communication fee for uploading web-page.
MNWIDPP and/or Division No.3, DWIDP	1. Support Kabilash Village for monitoring/data processing/up-loading to internet web-pages of rain gauges on Chainage 10 km of N-M highway. 2. Support Kabilash village technically and seek financial support to maintain following equipments which JICA will be provided for rainfall monitoring one compute with software, one USB, one CDMA phone , one automatic rain gauge, one manual rain gauge.
District Media Association	Broadcast information of traffic obstacles/early warming under heavy rain by radio, TV, and newspaper (ex. Kalika FM Bharatpure Chitwan)
Hotels in Bharatpur, Mugling	Display information of traffic obstacles/early warning under heavy rain to hotel facilities users.

Table 3 Implementation Organization Members for Disaster Management for Kabilash Village

Organization	Role
Kabilash VDC Secretary (Project Chief)	Act on disaster management generally in Kabilas Village.
VDC Staff	Support VDC Secretary.

Early Warning/Evacuation Team	1. Monitor of automatic at Kabilash VDC (Chainage 10km of the N-M highway) as follows. Once a day and or '12 hour half-value rainfall amount' is over 60 mm (noticed by buzzer and or inform to mobile phone of responsible person)': compute from hourly rainfall data into '12 hour half-value rainfall amount', Warning dissemination according to warning level depending on threshold of '12 hour half-value rainfall amount' 2. Monitoring manual rain gauge at Kabilash VDC (Chainage 10km of the N-M highway) once a day for subservient data.
Disaster Education/ Hazard Map Team	1. Prepare hazard map with study team, DWIDP, and NGO/RRN. 2. Provide disaster education to school and villagers.
Simple Structural Measure/ Forest Plantation Team	1. Conduct/maintain simple structural measure at crossing stream of chainage 11km +500 (woks completed on 16 June 2008) 2. Plan additional simple structural measure, forest plantation to protect soil erosion and income generation
MNWIDPP and/or Division No.3 of DWIDP	Advice/support on disaster management activities to Kabilash village.

Table 4 Equipments for Road Early Information System

Equipment Installed site	Maintenance Responsibility	Computer software	UPS 4 hour backup	CDMA phone with modem	Automatic recording rain gauge	Manual (Non-recording) Rain gauge	Road notice board
DWIDP Kathmandu	DWIDP	(1)	(1)				
		Procured in 2007 (now used by the Study Team)					
District Police office	DPO	1	1	1			
Division Road office, Bharatpur	DRO	1	1	1	1	1	
N-M Highway,chainage 1km Anpturi Police Station	DPO						1
N-M Highway, chainage 10km Kabilash VDC	Kabilash VDC supported by DWIDP	1	1	1	1	1	
N-M Highway, chainage 11km+300m, beside Kahale river	DRO					(1)	
				Installed by DOR in 2003			
N-M Highway, chainage 21 km	DRO					1	
N-M highway, chainage 31km	DRO					1	
N-M highway chainage 36km, on Mugling Intersection	DRO						1
Procurement of 2008 by JICA		3	3	3	2	4	2

6. Agenda and Participants List of 2nd Committee Meeting of Chitwan District Disaster Management Partnership Committee

2nd Committee Meeting of
Chitwan District Disaster Management Partnership Committee
For
The Pilot Projects
Early Road Information System and Disaster Management for Kabilash Village

Agenda

Date/Time: 20th (Thursday) November, 2008 From AM 9:00 – 14:00
Place: The Royal Century Hotel Meeting Room;
Bharatpur Height, Chitwan, Tel: 56-525865
Registration: 9:00-10:00
Agenda:
Facilitator; Mr. Shanamukesh Chandra Amatya, DWIDP
(1) Opening (10:00-10:20)

1) Introduction to Meeting's Agenda by Mr. Shanamukesh Chandra Amatya, DWIDP
2) Opening Address by Mr. Ratna Raj Pandy, CDO, Chitwan District
3) Outline of Pilot Project and Role of the Committee by Mr. Eto, JICA Study Team
4) Self Introduction

(2) Result of Pilot Project and Plan of Next Year (10:20-10:40)

1) Early Traffic Information System by Police Office Team
   By Mr. Prakash Malla, Inspector, DPO
   - Result of Operation
     - General Information sharing with other Operation Team
     - Public Information (Notice Board/ Uploading/ Kalika FM)
     - Case Study in Road Blockade by Rock Failure in 14th August
   - Operation Cost
   - Issues on Operation and Solutions
   - Plan of Next Year
     - Organization plan

- Budget preparation

2) Early Traffic Information System by Road Office(10:40-11:00)
   By Mr. Bijaya Chapagain, Engineer, DRO
   - General Information sharing with other Operation Team
   - Case Study in Road Blockade by Rock Failure in 14th August
   - Operation Cost
   - Issues on Operation and Solutions
   - Plan of Next Year
     - Organization plan
     - Budget preparation
3) Result of Disaster Management in Kabilash Village
   By Staffs of Kabilash Village
   - Result of Pilot project
     - Activity of Early Warning/ Evacuation Team
     - Activity of Disaster Education/ Hazard Map Team
     - Activity of Structural Measure/ Forest Plantation Team

(3) Question/ Answer and Discussion (11:20-11:40)

- Tea Break: 11:40-12:00-

(4) Evaluation of Pilot project (12:00－12:10)
By Study Team

(5) Discussion on Sustainable System (12:10-12:40)

(6) Closing Remark by Mr. Ratna Raj Pandy, CDO, Chitwan District (12:30-12:40)

- Lunch: 12:40-14:00-

SN	Name	Organization	Position	Remarks
1	Mr. Ratna Raj Pandey	District Administration Office, Chitwan	CDO	
2	Mr. Ghyan Bikram Shah	District Police Office Chitwan	SP	
3	Mr. Rajendra Raj Sharma	Divisional Road Office, Bharatpur	Chief Divisional Road Office	
4	Mr. Humakanta Bhurtel	Divisional Road Office	DRO Engineer	
5	Mr. Bijaya Chapagain	Divisional Road Office	DRO Engineer	
6	Mr. Shanmukesh Chandra Amatya	Department of Water induced Disaster Prevention Program	Senior Divisional Hydro geologist	Chief Landslide Section
7	Mr. Saroj Pandit	Mugling Narayanghat Water induced Disaster Prevention Program	Project Manager	
8	Mr. Pardhun Kumar Khadka	Kabilash Village Development Committee	Kabilash VDC Secretary	
9	Mr. Ajay Paudel	Kabilash Village Development Committee	Kabilash VDC Staff	
10	Ms.Saraswati Adhicari	Kabilash Village Development Committee	Kabilash VDC Staff	
11	Mr. Sukman Tamang	Kabilash Village Development Committee	Kabilash VDC Staff	
12	Mr. Nar Bahadur Lama	Kabilash Village Development Committee	Kabilash VDC Ward Representative	
13	Mr. Bhob Bahadur Gurung	Kabilash Village Development Committee	Disaster Education Team Member	
14	Mr Tek Bahadur Gurung	Kabilash Village Development Committee		
15	Mr. Nutan Pokharel	Rural Reconstruction Nepal	Engineer	
16	Mr. Tanka Upreti	Rural Reconstruction Nepal	District Coordinator	
17	Mr. Anjit Gurung	Rural Reconstruction Nepal	Instructor	
18	Mr. Prakash Sayami	Kalika FM	General Manager	
19	Mr.Devkota	Kalika FM	Station Manager	
20	Ms. Laxmi Dhakal	Kalika Fm	Repoter	
21	Mr. Tsumori Yusuke	JICA	Assistant Residential Representative	
22	Mr. Saurab Rana	JICA	Program Officer	
23	Mr. Eto	JICA STUDY TEAM	Team Leader	
24	Mr. Mori	JICA STUDY TEAM	Road Disaster Management	
25	Mr. Kuwano	JICA STUDY TEAM	Environment/ Social Consideration	
26	Mr. Adhikari	JICA STUDY TEAM	Geologist	
27	Mr. Shah	JICA STUDY TEAM	Office Secretary	
28	Mr. Roshan Shakya	JICA STUDY TEAM	Language Interpreter	

7. Agenda and Participants List of 2nd Advisory Committee Meeting

2nd Advisory Committee Meeting
On
Regular Operation and Maintenance for
Narayangharh-Mugling (N-M Highway Early Information System and;
Water Induced Disaster Management System for Kabilash Village)

Agenda

Date/Time: November 24(Monday), 2008 14:00-16:00
Place: Seminar Room of Department of Water Induced Disaster Prevention (DWIDP)
Agenda

(1) Opening Speech (5min): 14:00 - 14:05
By Mr. S. C. Amatya; Senior Divisional Hydrogeologist, DWIDP (Facilitator of the Meeting)

(2) Outline of Two Systems (20 min): 14:05 - 14:25
by Mr. Mori Study Team

(3) Evaluation and Suggestion by the Study Team
by Mr. ETO Team Leader of Study Team (30 min): 14:25 – 14:55

(4) Discussions for Sustainable Implementation of Systems (50 min): 14:55 – 15:45

(5) Wrap up remark: by Mr. S.C. Amatya (15 min): 15:45 – 16:00

S. No.	Name	Designation	Organization	Remarks
1	Mr. Khom Raj Dahal	Act. DG	DWIDP	
2	Mr. S. C. Amatya	SDE	DWIDP	
3	Mr. Shree Kamal Dwivide	Geologist	DWIDP	
4	Mr. Mekha Sharma	SDE	DWIDP	
5	Mr. Dileep Kumar Pokharel	SDE	DOR	
6	Mr. Vijay Chapagain	SDE	DOR	
7	Mr. Hanko Michinory	JICA Expert	DOR	
8	Mr. Thir Bahadur GC	Under Secretary	MoHA	
9	Mr. Dhan Bahadur Tamang	DG	DoLIDAR	
10	Mr. Y. Tsumori	Representative	JICA Nepal	
11	Mr. Saurab Rana	Program Officer	JICA Nepal	
12	Mr. M. Eto	Team Leader	JICA Study Team	
13	Mr. M. Mori	Team Member	JICA Study Team	
14	Mr. T. Kuwano	Team Member	JICA Study Team	
15	Mr. Sujan Raj Adhikari	Geologist	JICA Study Team	

8. Agenda, Participants List and Minutes of Meeting (M/M) of 2nd Steering Committee Meeting

Final Steering Committee Meeting

On

The Study on Disaster Risk Management for Narayangharh- Mugling Highway

Agenda

Date/Time: November 27th, 2008 14:00-15:00

Place: Meeting Room or MOW Hall

Agenda

(1) Opening Speech (5min):

Mr. Shadamukesh Chandra Amatya; the Leader of Countrpart Team, Chief, Landslide Section, DWIDP

(2) Major Output of the Study :(20 min)

by Mr. Masatoshi Eto, Study Team

1) Composition of Reports
2) Briefing on Main Report

(3) Report on Pilot Projects (15 min)

by Mr. Mori Study Team

1) Traffic Early Information System
2) Disaster Mitigation Activity in Kabilash Village
3) Evaluation on Pilot Project

(4) Discussions (15 min) by Attendants in the Meeting

- Sustainable Implementation of Basic Strategy
- Maintenance of Equipments

(6) Closing Remark (5 min): by Mr. Shankar Prasad Koirala, MOWR

S. No.	Name	Designation	Organization	Remarks
1	Mr. Shankar P. Koirala	Secretary	MOWR	
2	Mr. Khom Raj Dahal	Act. DG	DWIDP	
3	Mr. Tulashi P. Sitaula	DG	DOR	
4	Mr. Shiv Chandra Jha	DMG	NEA	
5	Mr. Shanmukhesh C. Amatya	SDC	DWIDP	
6	Mr. Shree Kamal Dwivedi	Geologist	DWIDP	
7	Mr. Hanko Michinory	JICA Advisor	DOR	
8	Mr. Y. Tsumori	Representative	JICA Nepal Office	
9	Mr. Saurab Rana	Program Officer	JICA Nepal Office	
10	Mr. Eto Masatoshi	Team Leader	JICA Study Team	
11	Mr. Mori Mikihiro	Team Member	JICA Study Team	
12	Mr. Kuwano Takeshi	Team Member	JICA Study Team	
13	Mr. Sujan Adhikari	Geologist	JICA Study Team	

MINUTES OF THE FINAL STEERING COMMITTEE MEETING

OF

THE STUDY ON DISASTER RISK MANAGEMENT FOR NARAYANGHARH – MUGLING HIGHWAY

AGREED UPON BETWEEN

DEPARTMENT OF WATER INDUCED DISASTER PREVENTION, MINISTRY OF WATER RESOURCE,

DEPARTMENT OF ROAD, MINISTRY OF PHYSICAL PLANNING AND WORKS,

AND

JICA STUDY TEAM ON THE DISASTER MANAGEMENT FOR NARAYANGHARH - MUGLING HIGHWAY

Katmandu, 27 November 2008

Nov 30, 2008

Mr. Shyam P. Rajbhandari	Mr. Tulasi P. Sitaula	Mr. Masatoshi [illegible]
Act. Director General, Department of Water Induced Disaster Prevention, Ministry of Water Resources	Director General, Department of Roads, Ministry of Physical Planning and Works	Team Leader JICA study Team on the Disaster management for Narayangharh – Mugling Highway

Government of Nepal
Ministry of Physical Planning & Works
Department of Roads
Babar Mahal

FERM for Road Disaster -JICA-

1. Approval of the Draft Final Report and discussion on modification for the Final Report

1-1. Approval of the draft final report
The study team explained the draft final report. And the steering committee approved the contents of the report on 27th November, 2008.

1-2. Additional modifications
- It is confirmed that if other modifications are required, DWIDP and DOR will submit to the Study Team by 15 December 2008 by the document.
- The Study Team will answer for modifications requested until the end of December, 2008.

1-3. Numbers of copies for final report is confirmed as follows;

Volume I: Summary	25 copies
Volume II: Main Report	25 copies
Volume III: Data and Drawing	25 copies
Volume IV: Technical Advice	25 copies

2. Sustainable implementation of basic strategies
The following implementations are confirmed.
2-1. Five strategies for Narayangharh Mugling Highway (N-M highway)
- Funds for structural measures suggested by the Study will be managed by DWIDP and DOR, and demarcation of the measures will be further discussion of the two departments.
- Regular maintenance and quick responses suggested by the Study will be conducted by the Division Road Office Bharatpur.
- Maintenance of sabo facilities suggested by the Study will be conducted by Mugling-Narayangharh Water Induced Disaster Prevention Project (MNWIDPP) and/or No3. Division Office of DWIDP.
- N-M highway early information system (NMHEIS) will be maintained by Division Road Office Bharatpur and related organizations of Chitwan District. DWIDP will coordinate and support the NMHEIS.
- Water-induced disaster management system for Kabilash Village (WIDMSKB) will be coordinated and supported by DWIDP.
- Annual schedule/activities of NMHEIS and WIDMSKB as Annex 2 is suggested by the Study will be coordinated by DWIDP. DWIDP will manage rainfall data and analyze from disaster management view points such as modifying warning criteria.

2-2 Structural measure for Ruwa Khola/Marsyangdi Hydro power house
- Structural measure will be conducted by NEA with coordination and technical support by DWIDP.

3. Request of handing over of Equipment from JICA to Nepal Side
The Equipments as Annex 3 were installed by the Study to sustain the system. Nepal side will submit a request letter to JICA Nepal office and be received equipment from JICA with their responsibility organizations in the Government of Nepal. Nepal side will use the received equipment maximum effectively in further activities on the risk management for N-M Highway and others.

2

Annex 1 Attendance List

Mr. Shankar P. Koirala	Secretary, Ministry of Water Resources
Mr. Khom R. Dahal	Act. Director General, DWIDP
Mr. Tulashi P. Sitaula	Director General, DOR
Mr. Shiv C. Jha	Deputy Managing Director, NEA
Mr. Tsumori Yusuke	Representative, JICA Nepal Office
Mr. Sourab Rana	Program Officer, JICA Nepal Office
Mr. Hanko Michinory	JICA Advisor, DOR
Mr. Eto Masatoshi	Team Leader, JICA Study Team
Mr. Mikihiro Mori	Member, JICA Study Team
Mr. Takeshi Kuwano	Member, JICA Study Team
Mr. Shanmukhesh C. Amatya	Senior Divisional Hydrogeologist, DWIDP
Mr. Shree K. Dwivide	Engineering Geologist, DWIDP

Annex 2: Annual Schedule/Activities of NMHEIS and WIDMSKB

Activity Items	N-M highway early information system (NMHEIS)	Water-induced disaster management system for Kabilash Village (WIDMSKB)
April	- Annual planning by Chitwan division police office (CDPO), Division road office of Bharatpur(DROB), Kabilash Village Development Committee (KVDC)	
May (Before rainy season)	- Presentation of annual plan by DWIDP at Chitwan district disaster Preparedness Committee (CDDPC) to get suggestion, support, understanding from stake holders. - Advisory committee (central level) at Katmandu (DWIDP, DOR, MOHA, DoLIDAR of MOLD) to get suggestion, support, understanding of central level.	
	Public relation of NMHEIS	Disaster education for villagers and students
	- Joint drill training of NMHEIS and WIDMSKB	
November (After rainy season)	- Preparation of self-evaluation by CDPO, DROB, KVDC - Presentation of evaluation by DWIDP at Chitwan district disaster Preparedness Committee (CDDPC) to get suggestion, support, understanding from stack holders. - Advisory committee (central level) at Katmandu (DWIDP, DOR, MOHA, DoLIDAR of MOLD) to get suggestion, support, understanding of central level.	

Annex 3: Equipment to be Handed over from JICA Nepal Side

Equipment in DWIDP Head Office		
Item	Quantity	Responsible organization
Desktop Computer: OS WindowsXP 1 licensed; RAM 2 x 1GB; CPU Intel Pentium E 6320,1.86 ghz	1	DWIDP Head office
A3 Size Laser printer: Canon Laserjet LBP 3500	1	
A3 Size copier: Canon 2016J	1	
Software AutoCAD version 2008	1	
Microsoft Office 2007 box pack (MS Word, MS Excel, MS PowerPoint	1	
Software, Norton Antivirus 2007	1	
Strain gauge meter	1	
Pocket size GPS	1	

Equipment in Kabilash Village		
Item	Quantity	Responsible organization
Computer, HDD 120 GB, RAM 2 GB, HD-120 G	1	Kabilash Village Development Committee
Software Microsoft Office (Word, Excel, PowerPoint), latest version	1	
Software, Virus security	1	
UPS: Uninterruptible power supply, 4 hour backup	1	
CDMA phone	1	
Automatic recording rain gauge	1	
Manual (None recording) rain gauge	1	

Equipment in Division Road Office, Bharatpur		
Item	Quantity	Responsible organization
Computer, HDD 120 GB, RAM 2 GB, HD-120 G	1	Division Road Office, Bharatpur, DOR
Software Microsoft Office (Word, Excel, PowerPoint), latest version	1	
Software, Virus security	1	
UPS: Uninterruptible power supply, 4 hour backup	1	
CDMA phone	1	
Automatic recording rain gauge	1	
Manual (None recording) rain gauge at office roof, 21km and 31km of the N-M highway	3	

Equipment in Chitwan District Police Office		
Item	Quantity	Responsible organization
Computer, HDD 120 GB, RAM 2 GB, HD-120 G	1	Chitwan District Police Office
Software Microsoft Office (Word, Excel, PowerPoint), latest version	1	
Software, Virus security software	1	
UPS: Uninterruptible power supply, 4 hour backup	1	
Road Notice Board	2	

5

9. Agenda and Participants List of Reporting Session

Reporting Session
on
the Study Out Put
of
The Study on Disaster Risk Management for Narayangaharh – Muguling Highway

Agenda

Date/Time 28th November, 2008 From AM 10:00 – 12:00
Place: Seminar Hall of DWIDP
Agenda:

(1) Introduction to Meeting's Agenda by Mr. R Amatya; DWIDP

(2) Outline of the Study Result
by Masatoshi Eto; Team Leader, Study Team

(3) Structural Measure s to Reduce Risk Level of Narayangharh- Mugling Highway
by Mr. Saroj Pandit; Project Manager, M-N WIDPP, DWIDP

(4) Pilot Project on Road Early Information System
by Shanmukesh Amatya; Chief of Landslide Section, DWIDP

(5) Question and Answer, Discussion:

(6) Closing Remark: Mr. Yusuke Tsumori, Assistant Resident Representative or
DDG, DWIDP

- Lunch-

S. No.	Name	Designation	Organization	Remarks
1	Mr. Shanmukhesh C. Amatya	SD Hydrologist	DWIDP	
2	Mr. Prakash Man Shrestha	SDE	DWIDP	
3	Mr. B. M. Dhital	SDE	DWIDP	
4	Mr. Soraj Pandit	SDE	DWIDP	
5	Mr. Shree Kamal Dwivedi	Engineering Geologist	DWIDP	
6	Mr. Yuraj Bajracharya	Engineer	DWIDP	
7	Mr. Mahendra Pd. Badu	Engineer	DWIDP	
8	Mr. Khila Nath Dahal	Engineering Geologist	DWIDP	
9	Mr. Ajit Kumar Chaudhari	Project Manager	DWIDP, Shindhuli	
10	Mr. Pradip K. Sah	Engineer, Sabo	DWIDP	
11	Mr. Kamal Shrestha	Engineer, Sabo	DWIDP	
12	Mr. Raja Ram Shrestha	Hydrologist	DWIDP	
13	Mr. Komal Kariki	Project Imp. Officer	ADB	
14	Mr. Y. Tsumori	Representative	JICA Nepal Office	
15	Mr. Saurab Rana	Program Officer	JICA Nepal Office	
16	Mr. M. Eto	Team Leader	JICA Study Team	
17	Mr. M. Mori	Team Member	JICA Study Team	
18	Mr.T. Kuwano	Team Member	JICA Study Team	
19	Mr. Sujan Raj Adhikari	Geologist	JICA Study Team	

II

HYDROLOGY ANALYSIS

Table of Contents

II. HYDROLOGICAL ANALYSIS

2.1 Introduction

The Narayangharh-Mugling highway is the most important section of the national highway network for linking the capital Kathmandu with Terai and India (Fig 2.1.1). The highway was damaged by landslides and debris flow due to heavy rainfall of 446.2 mm/day on 31 July 2003. Hourly and daily rainfalls data of stations in study area are necessary for the appropriate threshold on early weaning for water induced disaster. Formulation of realistic early warning threshold depends solely on the availabilities and qualities of rainfall records and road closure information.

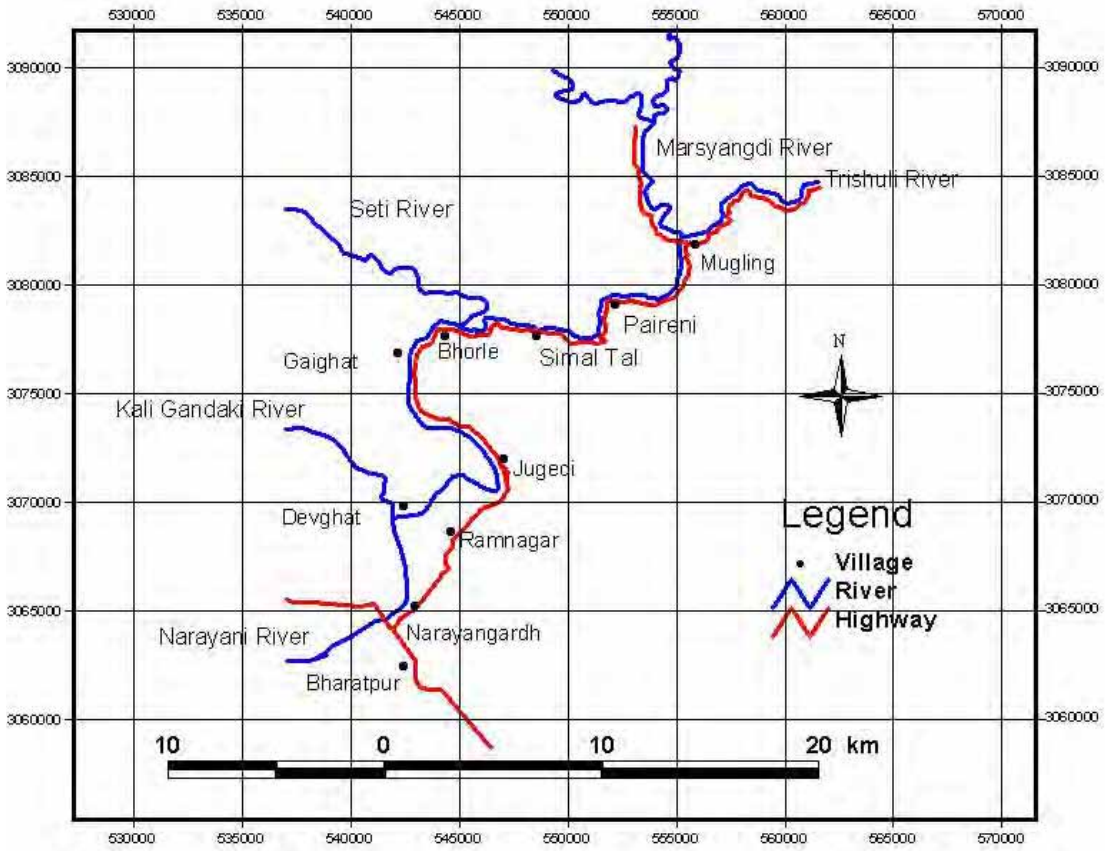

Figure 2.1.1 Narayangharh-Mugling Highway

2.2 Rainfall in General

Rainfall is primarily dominated by the monsoons characterized by heavy rainfall during the summer monsoon from June to September. The remaining period is known as extra-monsoon period receives only 20% of the annual rainfall. In Nepal, mainly convectional, orographical,

and monsoon rainfalls are prevailed, they are briefly discussed below.

Convectional rain: This rain occurs heavily but briefly with thunder and lightning. When warm air rises and reaches upper layer of the atmosphere, it cools and condenses. The condensed air forms cumulous clouds and cause rainfall. This type of rain is common during summer and in the hotter part of the day (noon).

Orographical rain: The high mountain forces the saturated air mass laden cloud to rise up and cool, and causes greater rainfall on the windward slope and rain shadow occurs on the leeward slope. For instance, the strong windward and leeward effects are observed in the Annapurna mountain area. Pokhara located at windward side of the Annapurna receives more than 3000 mm annual rainfall whereas the Mustang area leeward side receives less than 500 mm annual rainfall.

Monsoons rain: The summer monsoon developed over the Bay of Bengal and Indian Ocean is transported to Nepal by seasonal wind, and cause heavy rainfall in the whole country during summer monsoon season (June to September). Similarly, northeast monsoon makes small rainfall in the remaining period of the year.

2.3 Rainfall Stations

The rainfall stations along the Narayangharh-Mugling Highway were visited to know about operational conditions of the stations, data availability, and types of rain gauges installed.

2.3.1 Spatial Distribution

The spatial distribution of rainfall stations in and around study area is prepared (Figure 2.3.1). There is one station at Kahale Khola (at 11 km from Narayangharh on the highway) and other nearby stations from the highway are Devghat (at downstream of confluence of Kali Gandaki) and Bharatpur (at Bharatpur Municipality compound). All these 3 stations lie on the southern part of the highway. There are no rainfall stations along the highway on the northern part. The stations which are near from the northern part of the highway are Shakher and Majhimtar stations.

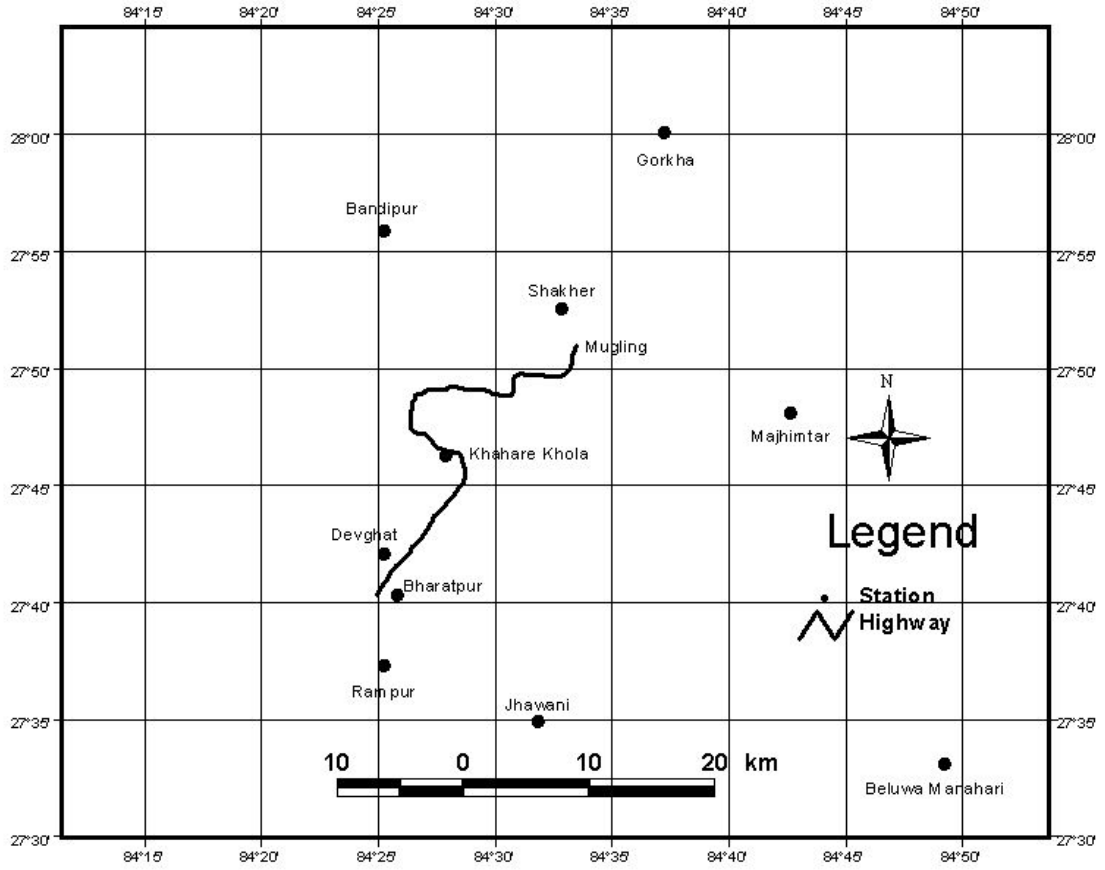

Figure 2.3.1 Rainfall Stations in and Around the Study Area

2.3.2 Operational Conditions and Data Availability

There are 3 rainfall stations in the study area. Present operational conditions of all the stations are satisfactory. The stations in the study area are illustrated briefly.

Kahale Khola Station: This station was established after 2003 disaster by the Divisional Road Office, Bharatpur at 11 km on Narayangharh-Mugling highway. Non-recording rain gauge was installed and daily rainfalls are being measured since 2004. Daily rainfall records of the station were provided for the period of May 2006 to August 2007. Present operational condition of the station seems satisfactory.

Devghat Station: This station is located at downstream of confluence of Kali Gandaki. At this station, both non-recording and recording types of rain gauges are installed by the Department of Hydrology and Meteorology (DHM). The hourly and daily rainfalls are being recorded at this station since 1998. Operational condition of the station at present is

satisfactory. Daily rainfalls data of 1998-2006 of this station were made available. Similarly, hourly rainfall charts of maximum annual daily rainfall days in 1998-2006 were requested to provide. But hourly rainfall charts were made available for some heavy rainfall days in the past. The days for which hourly rainfall charts made available are: 31 July 2003 (chart is useable: rainfall 446.2 mm), 9-10 September 2006 (charts are not useable because graphs were not plotted on both days: rainfall 376.4 mm and 289 mm) and 17 August 2007 (chart is useable: rainfall 197.4 mm).

Bharatpur Station: The station has non-recording rain gauge and is located in Bharatpur Municipality compound. This station is managed by Department of Hydrology and Meteorology (DHM). Discontinuous daily rainfall records of 2002-06 were made available, however, operational condition of the station seems satisfactory. Station in-charge reports daily rainfall and other meteorological data to Narayani Sub-Basin Office of DHM, Pokhara.

2.4 Analysis of 2003 Disaster Rainfall

The heavy rainfall on 31 July 2003 damaged the highway badly, therefore, hourly and daily rainfall data of that day are analyzed to get ideas on rainfall intensity and distribution pattern.

2.4.1 Rainfall Isohyets

The rainfall isohyets of 20 mm intervals were prepared for the day of 2003 disaster (Figure 2.4.1). The rainfall isohyets were prepared using daily rainfall of 11 stations in and around the study area. The rainfall isohyets showed 446.2 mm of rainfall was occurred at Devghat and its surrounding areas which caused the disaster on the Narayangharh-Mugling highway. The isohyets could be developed more precisely if there were other rainfall stations along the highway. The isohyets provide ideas on rainfall distribution patterns on the day of disaster. The isohyets show 280 - 446 mm rainfall occurred on the stretch of the highway where landslides and debris flows found most severe.

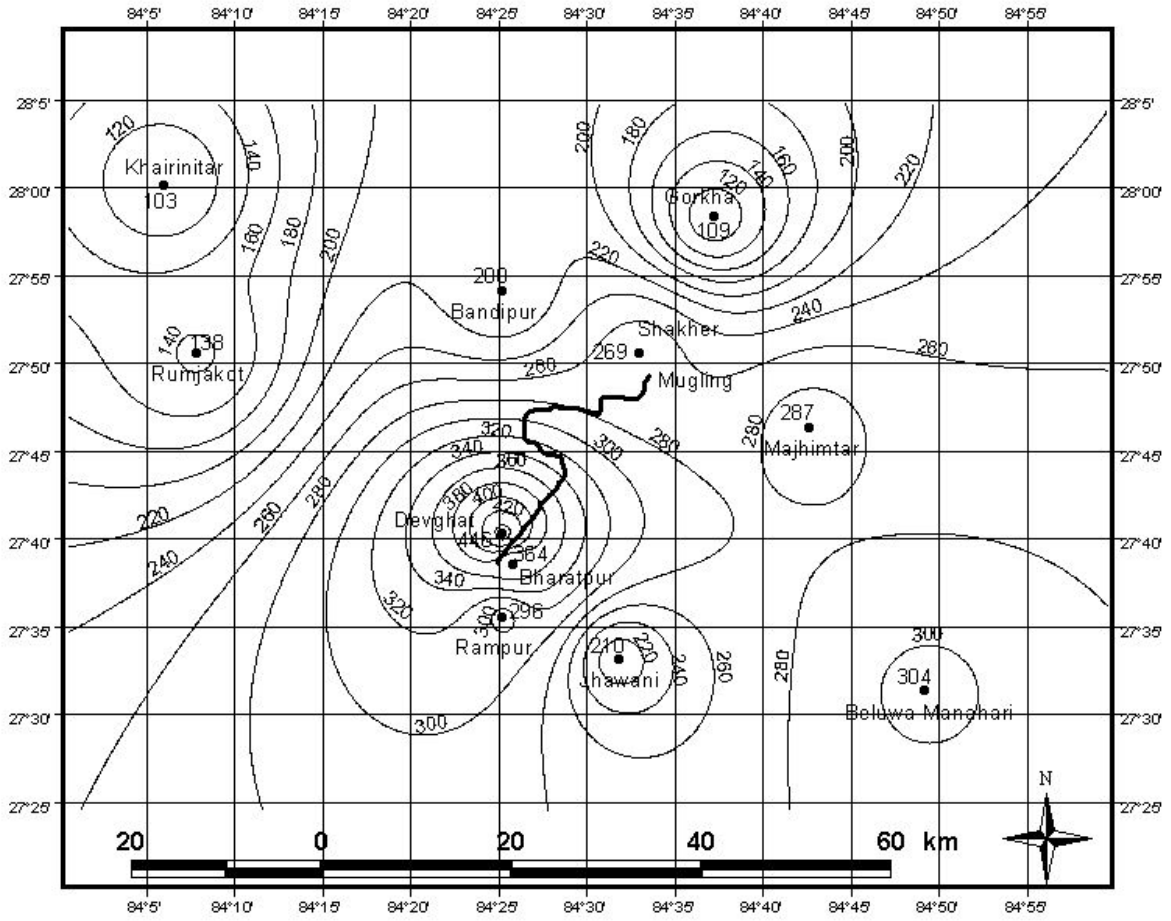

Figure 2.4.1 Daily Rainfall Isohyets (31 July 2003)

2.4.2 Rainfall Distribution Analysis

The rainfall distribution pattern of 31 July 2003 was studied. The rainfall chart of recording rain gauge of Devghat station showed rain started at 8:45 AM of 30 July and continued until 5:00 AM of 31 July, and the total rainfall amount was 446.2 mm in 20.25 hours (Figure 2.4.2). It showed about 25% of total rainfall (i.e. 114.5 mm) had occurred in the first 10 hours (between 8:45 AM and 18:45 PM), about 50% of total rainfall (i.e. 221.5 mm) had occurred in 12.5 hours (between 8:45 AM and 21:15 PM), and about 75% of total rainfall (i.e. 339.5 mm) had occurred in 14 hours (between 8:45 AM and 22:45 PM). It indicates that in 4 hours period (between 18.45 PM and 22.45 PM) 225.5 mm of rainfall occurred, and it devastated the highway with landslides and debris flows.

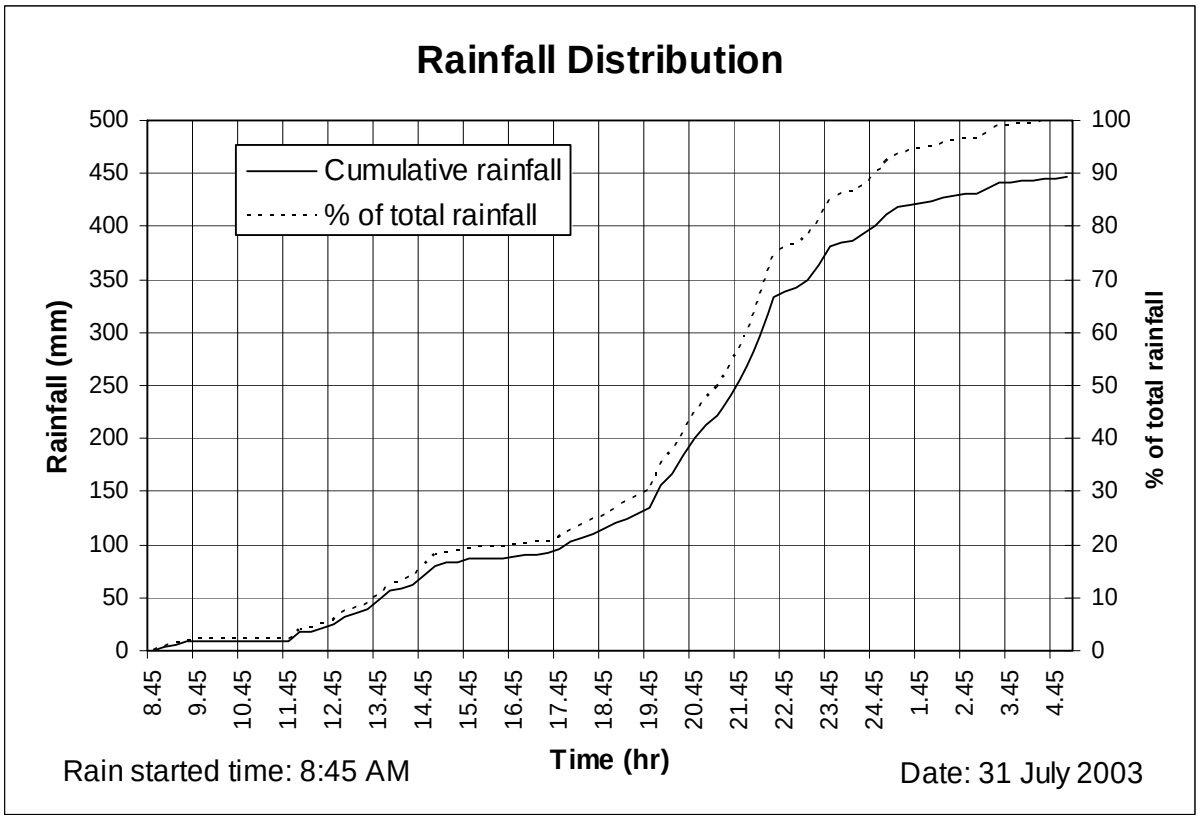

Figure 2.4.2 Rainfall Distribution on 31 July 2003 at Devghat station

2.4.3 Rainfall Intensity Analysis

The intensity of rain during 2003 disastrous rainfall was analyzed, and found that intensity of rain was extremely high. The maximum 1-hour, 6-hour and 12-hour rainfall intensities were 94.5 mm, 294.0 mm and 382.5 mm, respectively (Figure 2.4.4). The extremely high intensity rain (i.e. 94.5 mm/hr) after 13 hours of continuous moderate intensity rainfall led the devastating debris flows on streams crossing the highway. The rainfall with this pattern is considered most disastrous.

Similarly, rainfall intensity curve of 2003 disastrous rainfall is developed to use as a reference for getting ideas on devastating intensity of rain and thereby develop the warning system for the possibility of the highway disasters (Figure 2.4.4). The 1-hour, 3-hour, 6-hour, 9-hour and 12-hour intensities of rain were 94.5 mm/hr, 67.4 mm/hr, 48.1 mm/hr, 38.1 mm/hr and 31.9 mm/hr, respectively. The total amount of rainfall at specified time duration can be determined readily using this rainfall intensity curve. The relation used for developing rainfall intensity curve is given below.

$$I = \frac{C}{(t+a)^b} \qquad (1)$$

Where,

I = Rainfall intensity (mm/hr)

t = Time duration (min)

a, b, C = Constants

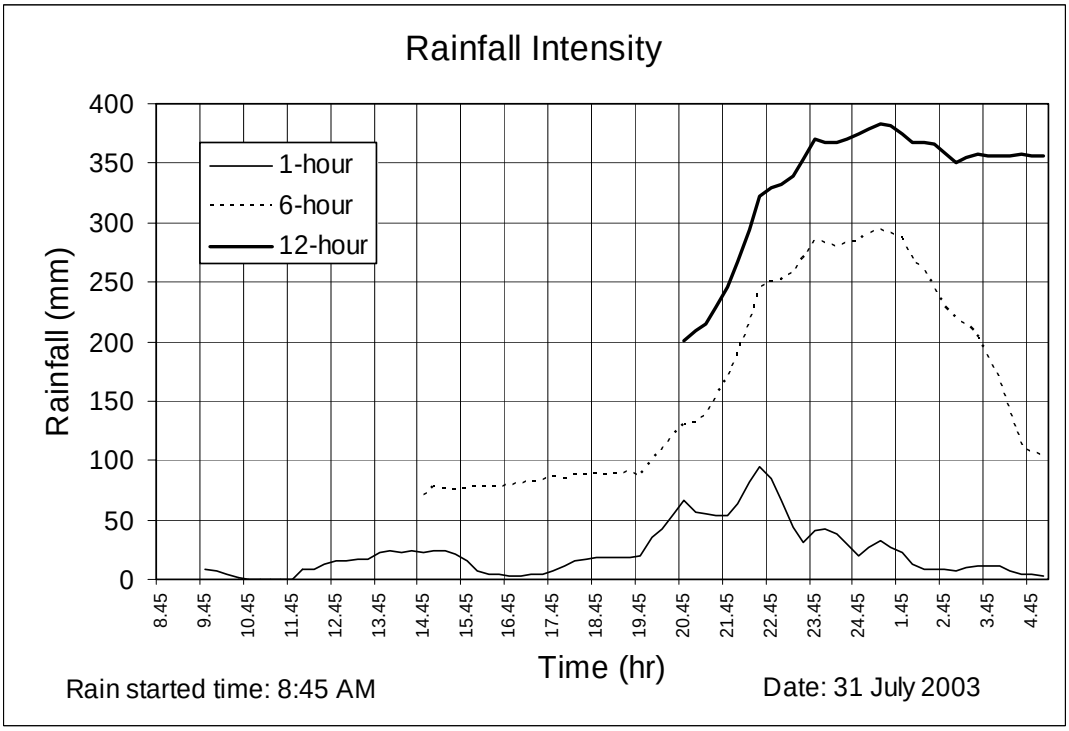

Figure 2.4.3 Rainfall Intensity on 31 July 2003 at Devghat Station

Conclusion: From the above analysis, it can be concluded that occurrence of very high intensity rain (i.e. more than 80 mm/hr) after almost 12 hours of continuous rainfall with considerable amount can cause devastating debris flow along the streams crossing the highway.

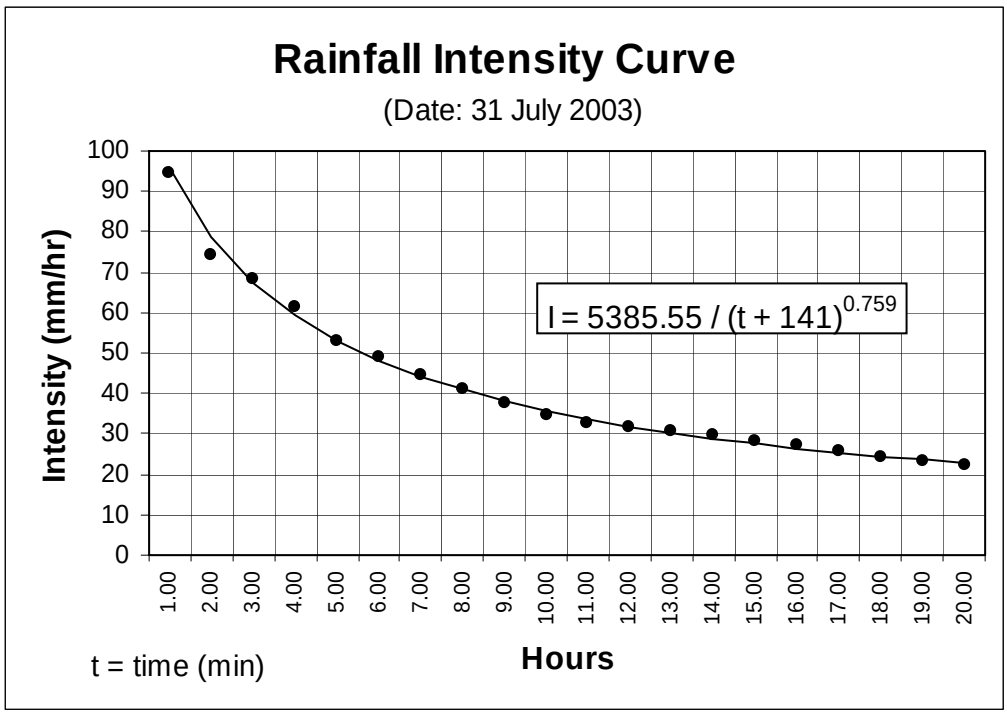

Figure 2.4.4 Rainfall Intensity Curve for 31 July 2003 (Devghat Station)

2.5 Daily Rainfall Patterns during Past Disasters

The daily rainfall patterns during 2003 and 2006 disasters and the pattern of recent heavy rainfall day were analyzed.

2.5.1 Daily Rainfall Pattern during 2003 Disaster

The daily rainfall patterns of Devghat and Bharatpur stations were analyzed (Figure 2.5.1). During 2003 disaster on the highway, at Devghat station daily rainfall pattern were 39.8 mm, 446.2 mm and 71.6 mm on 30th July, 31st July and 1st August, respectively. Further, at Bharatpur station during the disaster, daily rainfall pattern were 11.5 mm, 364.5 mm and 23.8 mm on 30th July, 31st July and 1st August, respectively. The rainfall pattern shows, at Devghat station, during 2003 disaster the maximum 2-day and 3-day rainfall were 517.8 mm and 557.6 mm, respectively. Similarly, during that disaster, the maximum 2-day and 3-day rainfall at Bharatpur station were 388.3 mm and 399.8 mm, respectively.

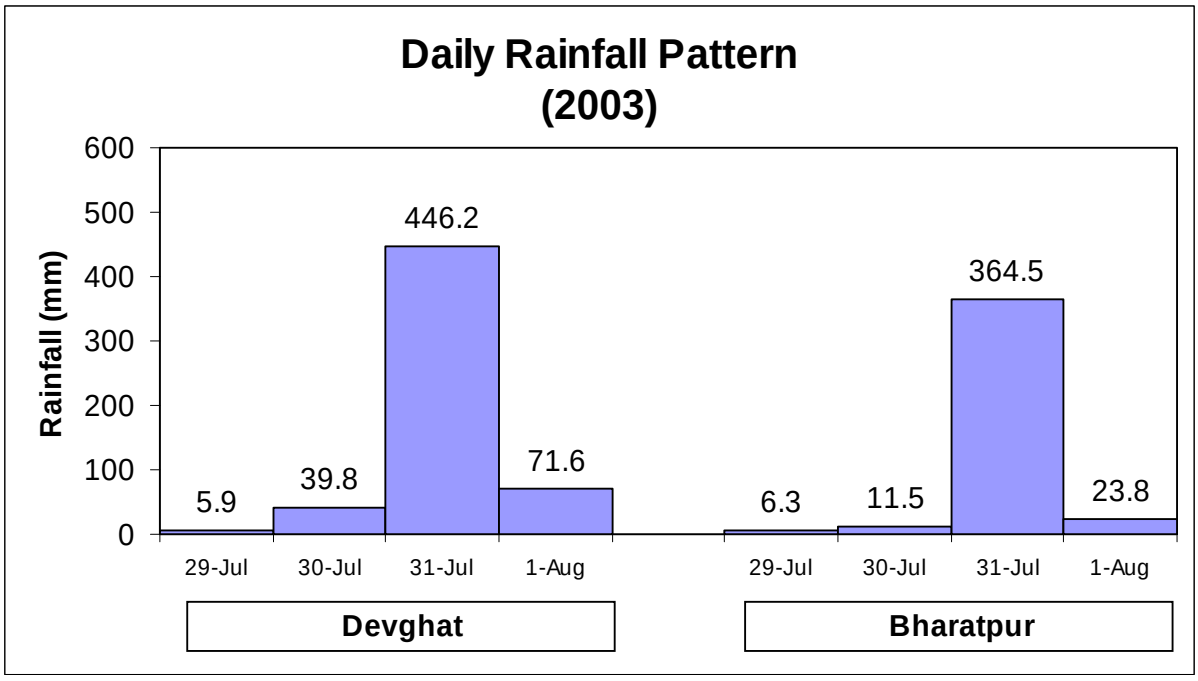

Figure 2.5.1 Daily Rainfall Pattern during 2003 Disaster

Conclusion: With analyzing daily rainfall pattern of Devghat station during 2003 disaster, it can be concluded that landslides and debris flow occur on the highway if rainfall continued for 2 days with considerable amount of rainfall on the first day and heavy rainfall of more than 300 mm on the second day.

2.5.2 Daily Rainfall Pattern during 2006 Disaster

The daily rainfall patterns of Devghat, Bhratpur and Khahare Khola stations were analyzed (Fig. 6.8). During 2006 disaster, at Devghat station daily rainfall pattern were 0.0 mm, 376.4 mm and 289.6 mm on 8th, 9th and 10th September, respectively. At Bharatpur station, daily rainfall pattern were 0.0 mm, 236.0 mm and 99.0 mm on 8th, 9th and 10th September, respectively. Further, at Khahare Khola station, daily rainfall pattern were 0.0 mm, 256.0 mm and 346.0 mm on 8th, 9th and 10th September, respectively. The rainfall pattern shows, during 2006 disaster, the 2-day rainfall were 660.0 mm, 335.0 mm and 602.0 mm at Devghat, Bharatpur and Khahare Khola stations, respectively. It shows that 2-day rainfall during 2006 disaster was more than 2003 disaster at Devghat station but slightly less at Bharatpur station.

Conclusion: With analyzing daily rainfall pattern of Devghat and Khahare Khola stations during 2006 disaster, it can be concluded that landslides and debris flow occur on the

highway if rainfall continued for 2 days with considerable amount of rainfall on the first day and heavy rainfall of more than 300 mm on the second day as concluded earlier.

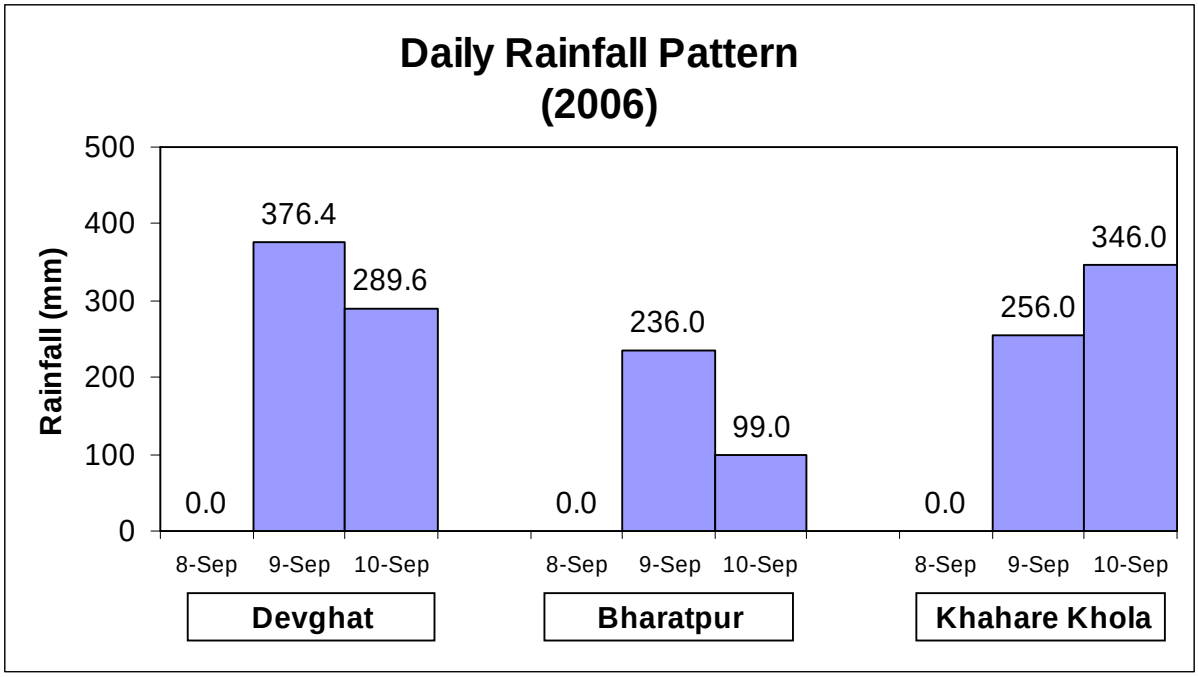

Figure 2.5.2 Daily Rainfall Pattern during 2006 Disaster

2.5.3 Daily Rainfall Pattern during Recent Rainfall Days

The daily rainfall patterns of Devghat, Bharatpur and Khahare Khola stations for recent heavy rainfall days on 16-17 August 2007 were analyzed (Figure 2.5.3). At Devghat station, daily rainfalls were 58.7 mm and 197.4 mm on 16th and 17th August, respectively. The maximum 1-hour rain intensity was 39.5 mm/hr during rainfall at Devghat. At Bharatpur station, daily rainfalls were 38.1 mm and 229.4 mm on 16th and 17th August, respectively. Further, at Khahare Khola station, daily rainfalls were 94.0 mm and 298.0 mm 16th and 17th August, respectively. The rainfall pattern shows, the 2-day rainfall were 256.1 mm, 267.5 mm and 392.0 mm at Devghat, Bharatpur and Khahare Khola stations, respectively. The highway condition was inspected by the JICA Study Team on 17 August after heavy rainfall. During inspection it has been observed that landslides were occurred at several places on the highway, and length workers were busy on clearing the landslides for easy movement of vehicles on the highway.

Conclusion: From the inspection of the highway, it can be concluded that highway is vulnerable to landslides when rainfall continues for 2 days with considerable amount of rainfall on the first day and heavy rainfall of more than 200 mm on the second day.

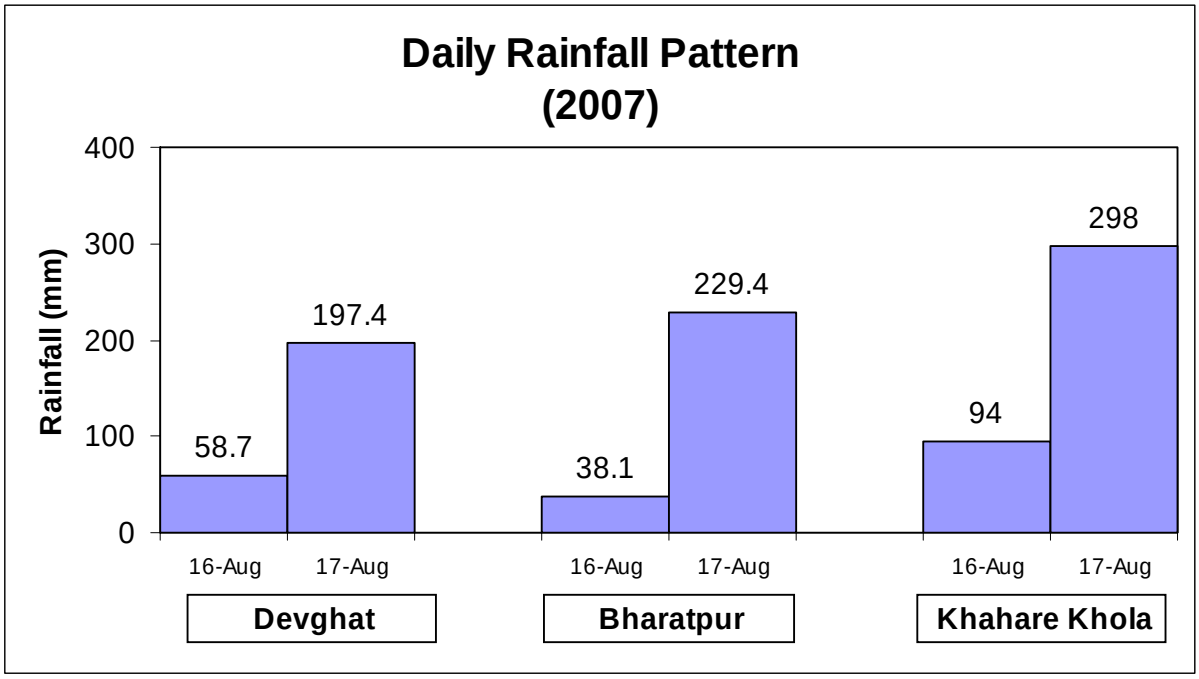

Figure 2.5.3 Daily Rainfall Pattern on Recent Rainfall Days

2.6 Analysis of Historical Time Series of Daily Rainfalls

Devghat station is the only nearby station from the highway with long time-series daily rainfall records (1998-2006). Therefore, daily rainfall records of Devghat station were use for analyzing the maximum annual 1-day, 2-day and 3-day rainfalls and their return period analysis.

2.6.1 Maximum 1-day, 2-day & 3-day Rainfalls

The maximum annual 1-day, 2-day and 3-day rainfall of Devghat station were analyzed for 1998-2006. The analysis of each category rainfall is illustrated.

Maximum 1-day Rainfall:

The daily rainfalls records of only past nine years (1998-2006) of Devghat station were available. Based on those daily rainfall records of the station, the maximum annual daily rainfalls of the station were sorted out (Appendix 2.1). The records show the highest value of the maximum annual daily rainfalls of 446.2 mm on 31 July 2003 and which is followed by 376.4 mm on 9 September 2006. Moreover, the lowest value of the maximum annual daily rainfall of 100.3 mm is found on 7 August 2005 (Figure 2.6.1).

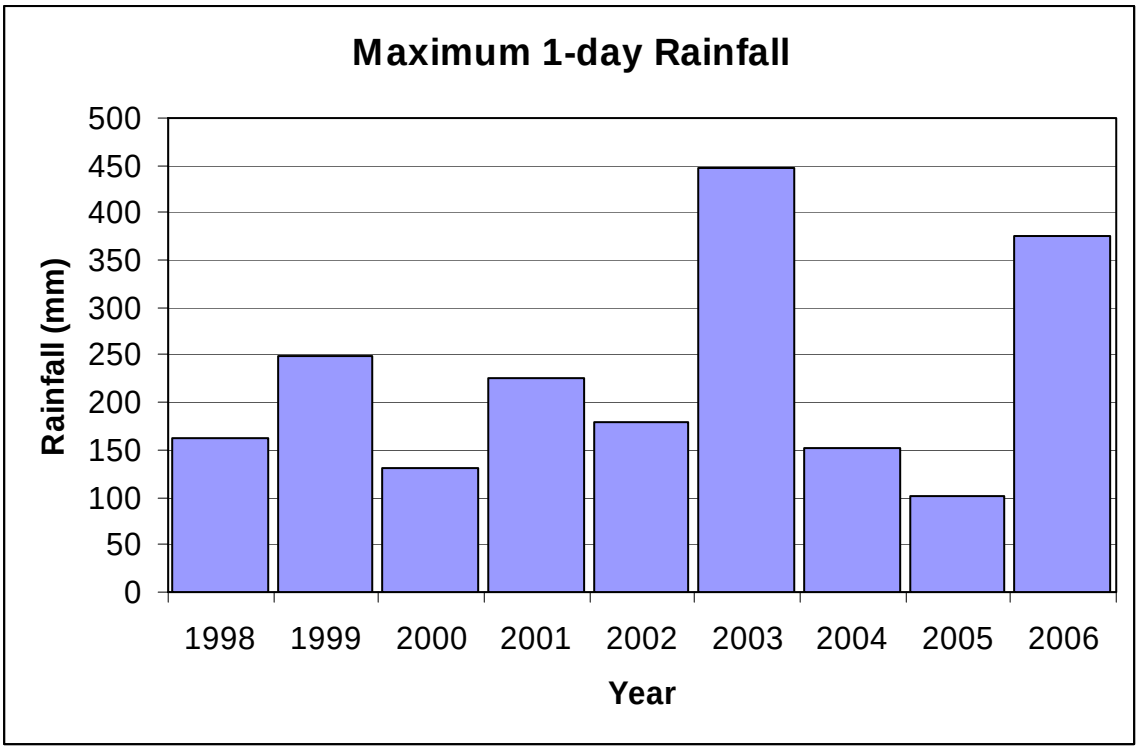

Figure 2.6.1 Maximum 1-day Rainfall (Devghat Station)

Maximum 2-day Rainfall:

Maximum 2-day rainfalls in each year at Devghat station were sorted out for 1998-2006 (Appendix 6.2). The highest value of maximum 2-day rainfall was 666.0 mm (during 9 & 10 September 2006) which is followed by 517.8 mm (during 31 July & 1 August 2003). The lowest value of maximum 2-day rainfall was 154.6 mm (during 6 & 7 August 2005). The maximum 2-day rainfall in each year of Devghat station is presented (Figure 2.6.2).

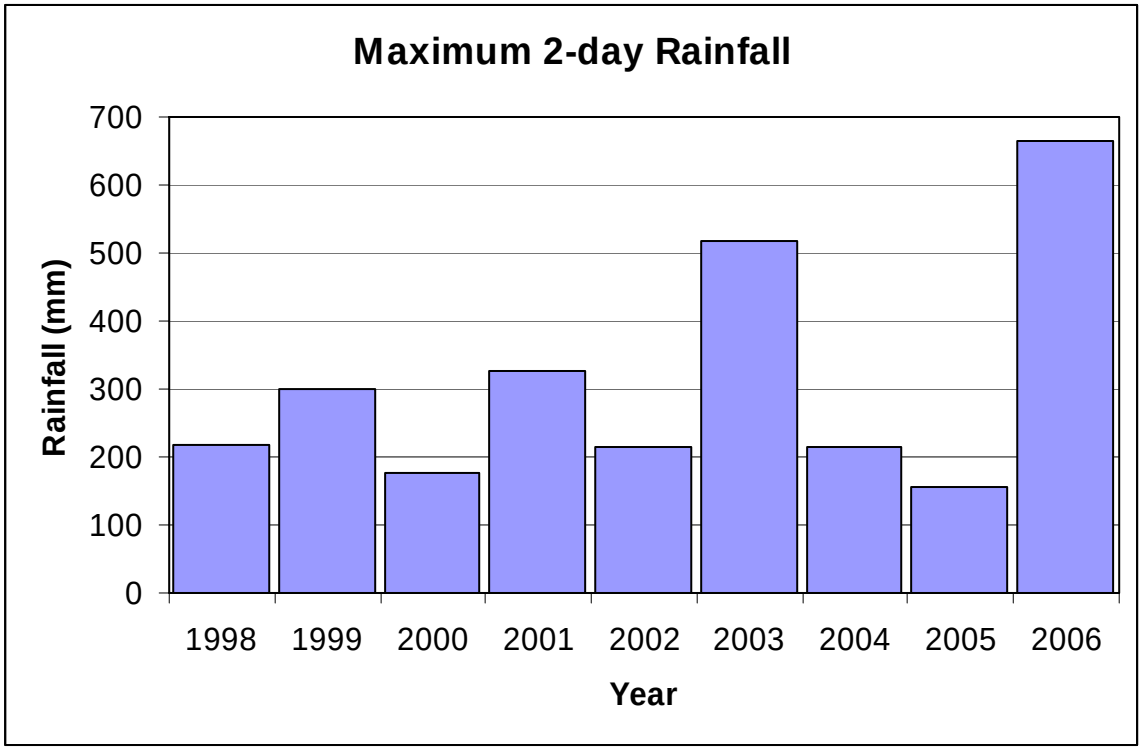

Figure 2.6.2 Maximum 2-day Rainfall (Devghat Station)

Maximum 3-day Rainfall:

Similarly, maximum 3-day rainfalls in each year of Devghat station were sorted out for the duration of 1998-2006 (Appendix 6.3). The highest value of maximum 3-day rainfall was 690.5 mm (during 9-11 September 2006) which is followed by 557.6 mm (during 30 July to 1 August 2003). The lowest value of maximum 3-day rainfall was 186.3 mm (during 6-8 August 2005). The maximum 3-day rainfall in each year of Devghat station is presented in graphical form (Figure 2.6.3).

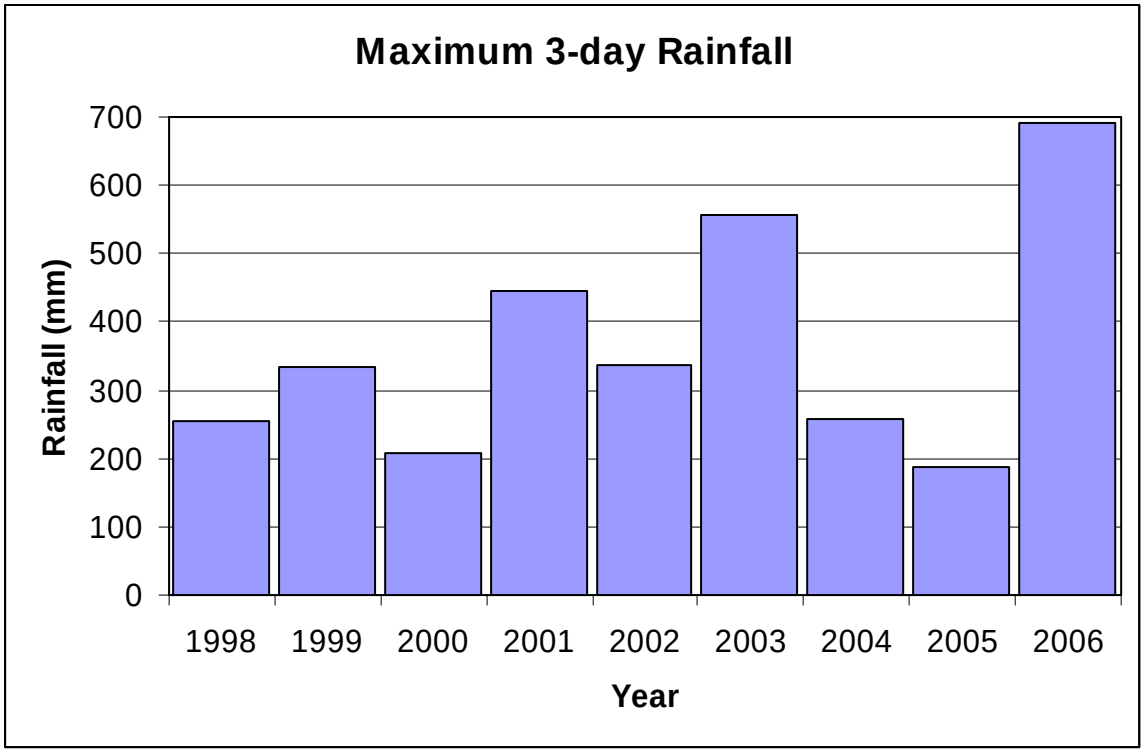

Figure 2.6.4 Maximum 3-day Rainfall (Devghat Station)

2.6.2 Return Period Analysis of 1-day, 2-day & 3-day Rainfalls

The return period of maximum annual 1-day, 2-day & 3-day rainfalls series were determined by employing various types of distribution functions. The historical daily rainfall time series data of 1998-2006 at Devghat station were used for this purpose.

Return Period of 1-day Rainfall:

The maximum annual daily rainfalls of past nine years (1998-2006) were analyzed using various distribution functions to know non-exceedance probability of certain levels of daily rainfalls. The probability plotting positions of observed maximum daily rainfalls were determined using Weibull method. Among the distribution functions, three parameters Lognormal distribution was found to be the best fitted for the maximum annual daily rainfalls data of the station (Fig.6.13). The domain, probability density function [f(x)], cumulative distribution function [F(x)] of Lognormal (3P) distribution are presented below.

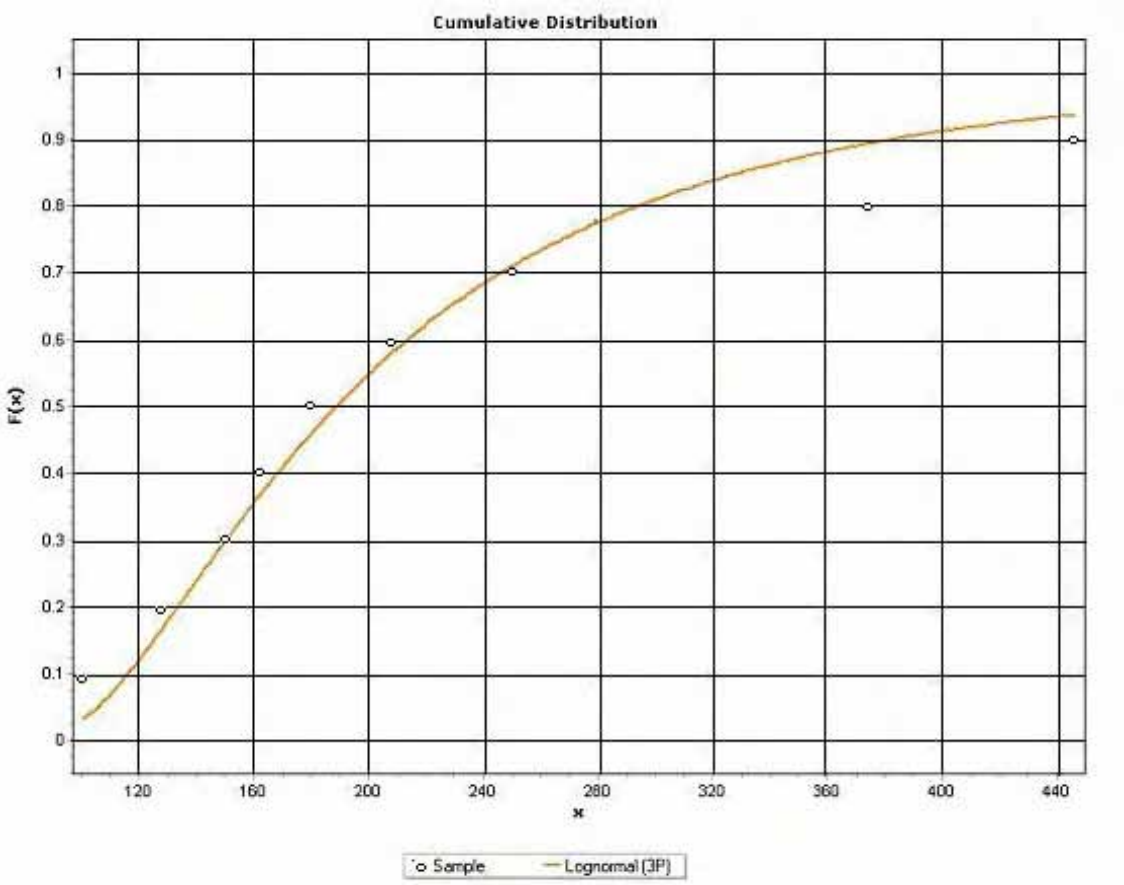

Figure 2.6.5 Lognormal (3P) Distribution Fitting for Maximum 1-day Rainfalls

Domain:

$\varepsilon < x < +\infty$ (2)

The functions are:

$$f(x) = \frac{\exp\left[-\frac{1}{2}\left\{\frac{\ln(x-\varepsilon)-\mu}{\sigma}\right\}^2\right]}{(x-\varepsilon)\sigma\sqrt{2\pi}} \quad (3)$$

$$F(x) = \phi\left[\frac{\ln(x-\varepsilon)-\mu}{\sigma}\right] \quad (4)$$

Where,

f(x) = Probability density function (pdf)

F(x) = Cumulative distribution function (cdf)

Φ = cdf of standard normal distribution

x	=	Variable (daily rainfall)
ε	=	Lower bound parameter or location parameter
μ, σ	=	Normal parameters

Kolmogorov Smirnov goodness of fit test was carried out to see the maximum deviation of the fitted curve. The maximum deviation (D) is determined as shown below.

$$D = \max\left|F_o(x) - S_n(x)\right| \quad (5)$$

$$S_n(x) = \frac{k}{n} \quad (6)$$

Where, $F_o(x)$ = the proportion of cases expected to have scores less than or equal to x, k = no. of observations less than or equal to x, and n = total no. of observations.

The values of the parameters in the distribution fitting are σ = 0.766, μ = 4.754 and ε = 72.616. Kolmogorov Smirnov goodness of fit value is 0.095. Further, cumulative distribution function of Lognormal (3P) distribution was applied to compute return periods of certain levels of daily rainfalls. It is found that 200, 300 and 400 mm daily rainfalls have return periods of 2, 5 and 10 years, respectively (Table 2.6.1).

Table 2.6.1 Return Period of 1-day Rainfall

S. N.	Daily Rainfall (mm)	Return Period (Year)
1	200	2
2	250	3
3	300	5
4	350	7
5	400	10
6	450	16

Return Period of 2-day Rainfall:

Probability analysis of maximum 2-day rainfalls was carried out using distribution functions. As in the case of maximum 1-day rainfall, three parameters Lognormal distribution best fitted with maximum 2-day rainfalls as well (Fig.6.14). The values of parameters in the distribution fitting are σ = 1.14, μ = 4.56 and ε = 143.92. Kolmogorov Smirnov goodness of fit value is 0.152.

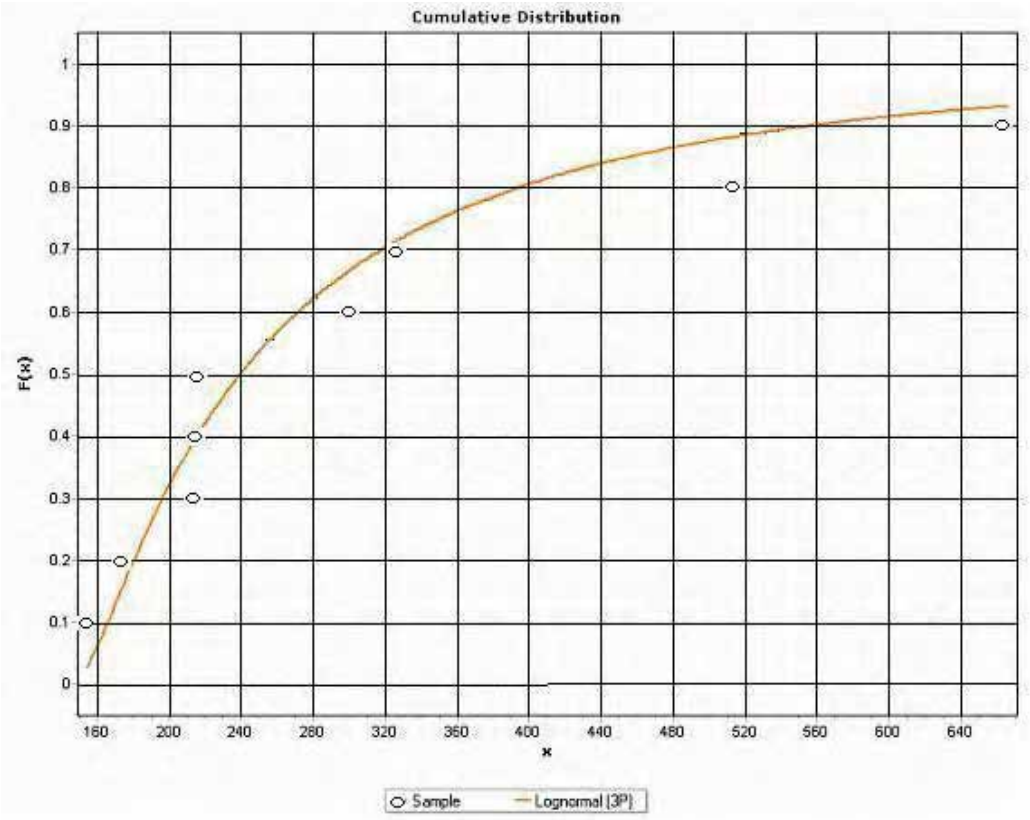

Figure 2.6.6 Lognormal (3P) Distribution Fitting for Maximum 2-day Rainfalls

Based on the cumulative distribution function of the Lognormal (3P) distribution, return period for particular levels of 2-day rainfalls were determined (Table 2.6.2). The return period of 240, 390, 465 and 550 mm of 2-day rainfalls are 2, 5, 7 and 10 years, respectively.

Table 2.6.2 Return Period of 2-day Rainfall

S. N.	2-day Rainfall (mm)	Return Period (Year)
1	240	2
2	305	3
3	350	4
4	390	5
5	430	6
6	465	7
7	480	8
8	520	9
9	550	10
10	600	12
11	650	15

Return Period of 3-day Rainfall:

Probability analysis of maximum 3-day rainfall of each year during 1998-2006 was analyzed by distribution functions. Generalized Pareto distribution function best fitted with maximum 3-day rainfalls series (Figure 2.6.3). The domain, probability density function [f(x)] and cumulative distribution function [F(x)] of Generalized Pareto distribution are as given below.

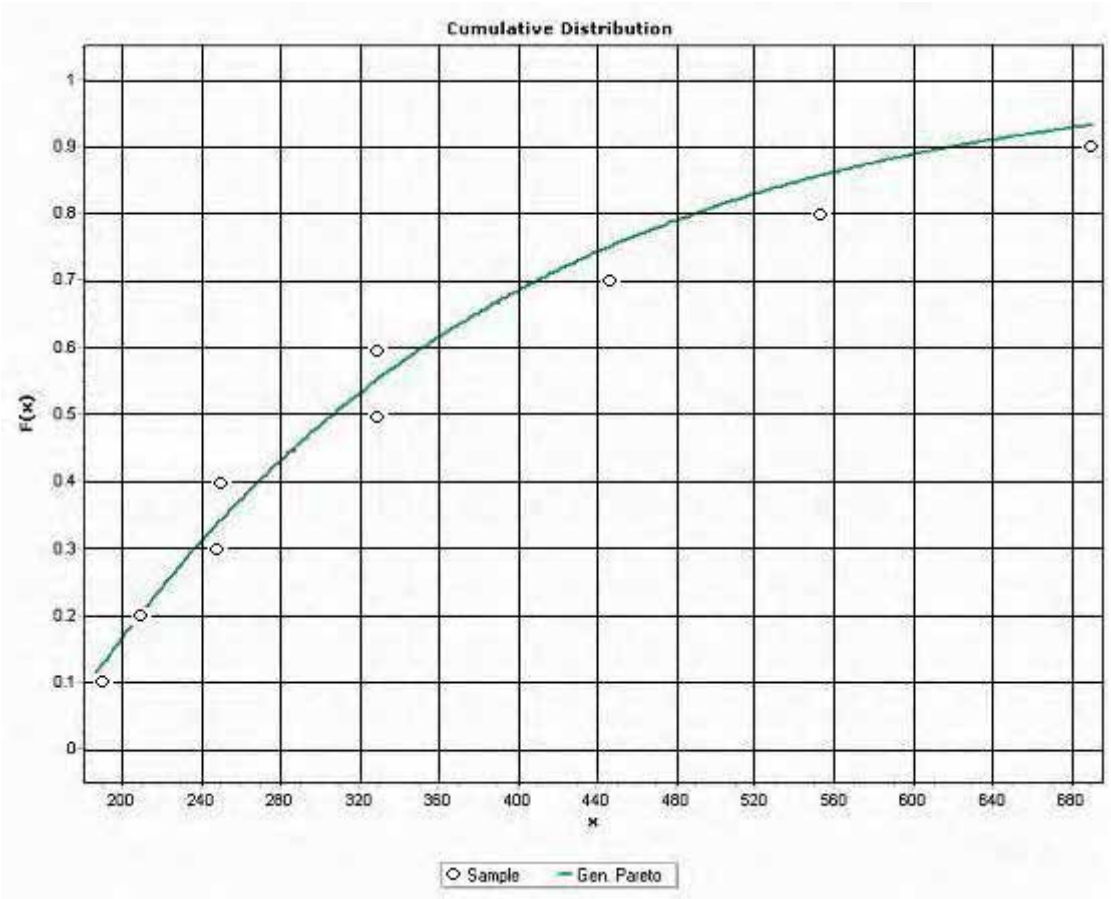

Figure 2.6.7 Generalized Pareto Distribution Fitting for 3-day Rainfalls

Domain:

$\mu \leq x < +\infty$ for $k \geq 0$ (7)

$\mu \leq x \leq - \sigma/k$ for $k < 0$ (8)

The functions are:

$$f(x) = \frac{1}{\sigma}\left[1 + \frac{k(x-\mu)}{\sigma}\right]^{-1-\frac{1}{k}} \quad \text{for} \quad k \neq 0 \quad (9)$$

$$f(x) = \frac{1}{\sigma}\exp\left[-\frac{(x-\mu)}{\sigma}\right] \quad \text{for} \quad k = 0 \quad (10)$$

$$F(x) = 1 - \left[1 + \frac{k(x-\mu)}{\sigma}\right]^{-\frac{1}{k}} \quad \text{for} \quad k \neq 0 \quad (11)$$

$$F(x) = 1 - \exp\left[-\frac{(x-\mu)}{\sigma}\right] \quad \text{for} \quad k = 0 \quad (12)$$

Where,

f(x)	=	Probability density function (pdf)
F(x)	=	Cumulative distribution function (cdf)
k	=	Shape parameter
σ	=	Scale parameter (σ > 0)
μ	=	Location parameter

The values of parameters in the distribution fitting are k = -0.062, σ = 214.25 and μ = 161.64. Kolmogorov Smirnov goodness of fit value is 0.102.

With the help of cumulative distribution function of the Generalized Pareto distribution function, return period for particular levels of 3-day rainfall were determined. The fitted distribution function shows that return period of 305, 490, 550 and 620 mm of 3-day rainfalls are 2, 5, 7 and 10 years, respectively (Table 2.6.3).

Table 2.6.3 Return Period of 3-day Rainfall

S. N.	3-day Rainfall (mm)	Return Period (Year)
1	305	2
2	385	3
3	440	4
4	490	5
5	520	6
6	550	7
7	570	8
8	600	9
9	620	10
10	640	11
11	680	16

2.7 Threshold Value of Rainfall for Early Warning

2.7.1 Estimation of Modified (H-hour half-value) Rainfall Amounts

The modified rainfall amounts of 6, 12 and 24-hour half-value were estimated using annual maximum daily rainfalls of 1998-2006. The daily rainfall amounts were divided by 24 to convert it to hourly rainfall amounts because H-hour half-value rainfall amounts are estimated based on hourly rainfalls. However, hourly rainfall data on the day of maximum rainfall in 2003 were derived from the rainfall recording chart. The relation used for estimation of T-hour half-value rainfall amounts is as shown in expression (13)

$RA_{Hhv}(t) = 0.5^{i/H} \times HR(i)$ (13)

Where,

$RA_{Hhv}(t)$ = rainfall amount of H-hour half-value of time 't'

i = 'i' hour before from time 't' (hour)

H = H-hour half-value: Half-value period of hourly rainfall reduction (hour)
H = 6, 12, 24

HR(i) = Hourly rainfall of 'i +1' to 'i' hour before from time 't'

2.7.2 Return Period Analysis of H-hour Half-value Rainfall Amounts

The frequency (return period) analysis of H-hour half life rainfall amounts was carried out using the most commonly used Lognormal (LN) distribution function. For frequency analysis, the maximum modified rainfall amounts of 6, 12 and 24-hour half value were computed for the maximum annual daily rainfall days during 1998-2006 at Devghat station. The computed maximum modified rainfall amounts of 6, 12 and 24-hour half-value were fitted with Lognormal (LN) distribution function and the required parameters were derived for return period analysis of a particular amount of modified rainfall of H-hour half-value (Figure 2.7.1-2.7.3). The relation of cumulative distribution function (cdf) of Lognormal (LN) distribution is as presented below:

$$F(x) = \phi\left[\frac{\ln(x) - \mu}{\sigma}\right] \quad (14)$$

Where,

F(x) = Cumulative distribution function (cdf)

Φ = cdf of standard normal distribution

x = Variable (T-hour half life rainfall)

μ, σ = Normal parameters

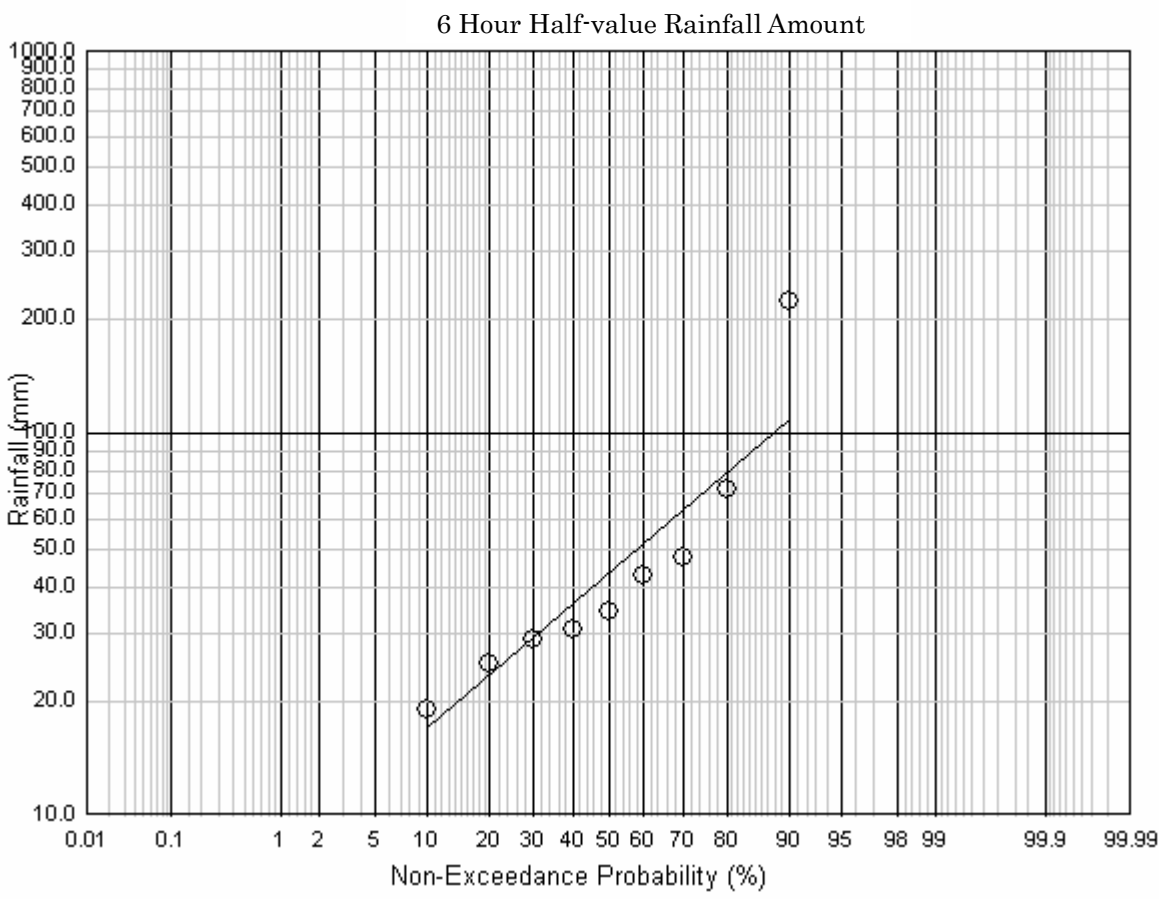

Figure 2.7.1 Lognormal Distribution Function Fitting of 6-hour Half-value Rainfall Amount

The parameters determined from the curve fitting of the 6-hour half-value rainfall are: μ = 3.758 and σ = 0.730. The return periods and respective 6-hour half-value rainfalls determined from the fitted curve of Lognormal (LN) distribution function are: 1-year (30 mm), 2-year (43 mm), 5-year (80 mm) and 10-year (110 mm).

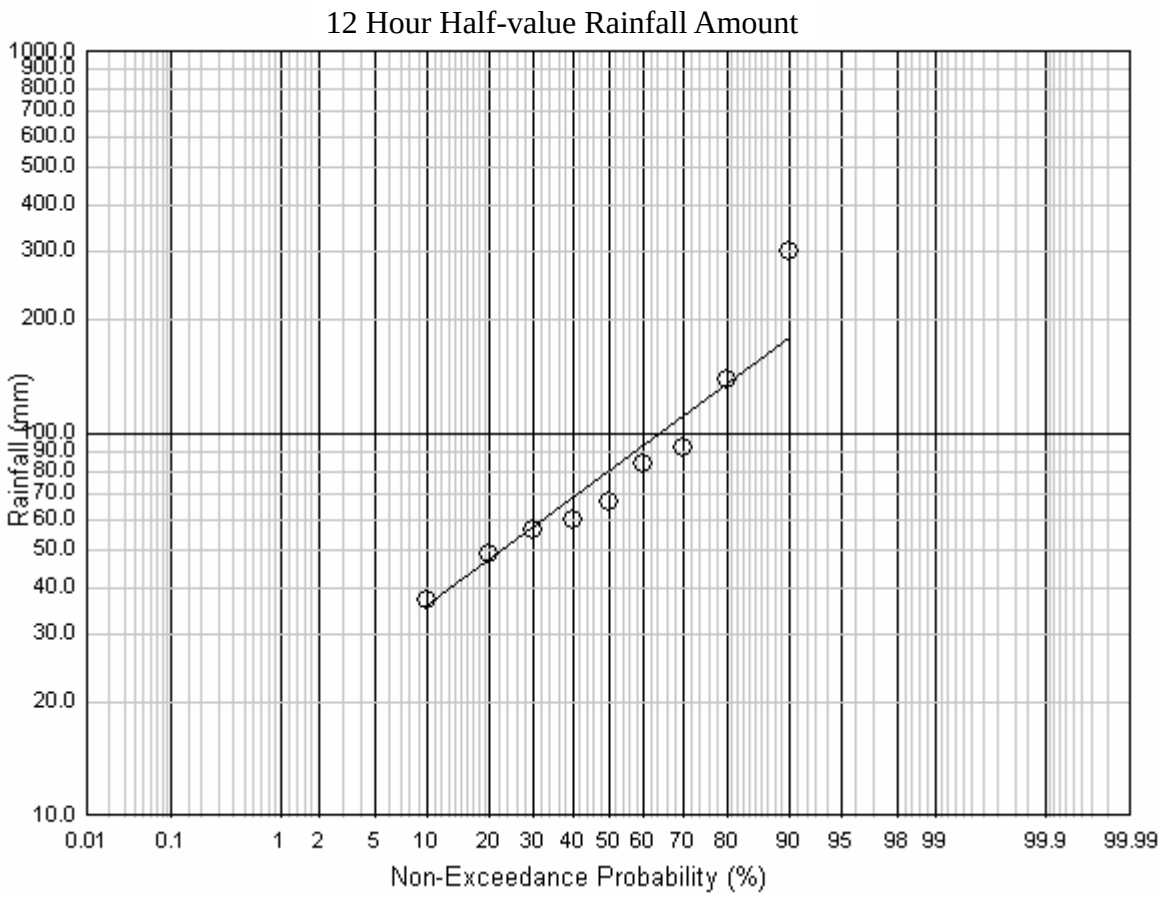

Figure 2.7.2 Lognormal Distribution Function Fitting of 12-hour Half-value Rainfall Amount

The parameters determined from the curve fitting of the 12-hour half-value rainfall are: μ = 4.383 and σ = 0.630. The return periods and respective 12-hour half-value rainfalls determined from the fitted curve of Lognormal (LN) distribution function are: 1-year (60 mm), 2-year (81 mm), 5-year (137 mm) and 10-year (180 mm).

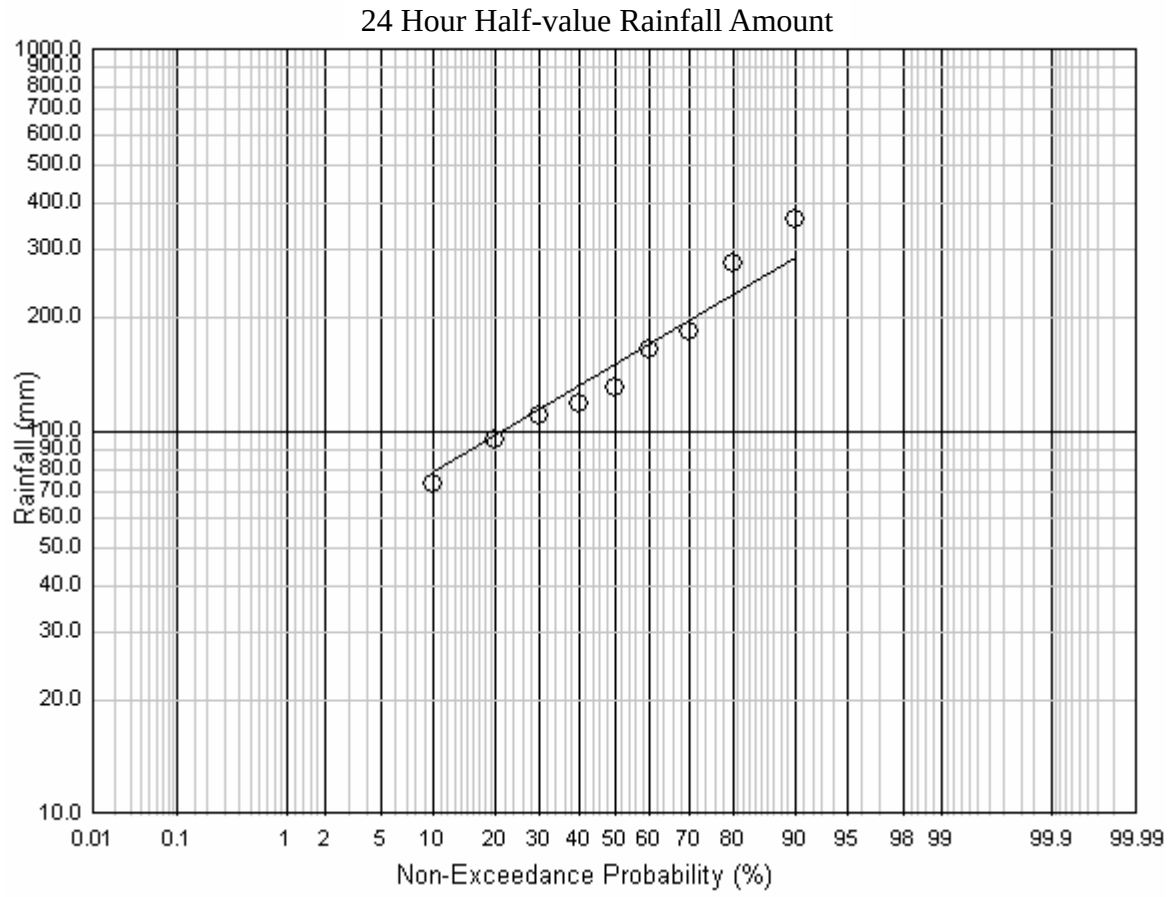

Figure 2.7.3 Lognormal Distribution Function Fitting of 24-hour Half Life Rainfall Amount

The parameters determined from the curve fitting of the 24-hour half life rainfall are: μ = 5.006 and σ = 0.508. The return periods and respective 24-hour half life rainfalls determined from the fitted curve of Lognormal (LN) distribution function are: 1-year (120 mm), 2-year (150 mm), 5-year (230 mm) and 10-year (290 mm).

2.7.3 Process of Threshold Rainfall Amount Determination for Early Warning

The maximum modified rainfall amounts of 6, 12 and 24-hour half-value were computed for the maximum annual daily rainfall days during 1998-2006 at Devghat station. The return periods of 6, 12 and 24-hour half-value rainfall amounts and 24-hour maximum recorded rainfall amounts were analyzed. The return periods of 6, 12 and 24-hour half-value rainfall

amounts of 2003 disaster are 85, 58 and 25 years, respectively. Similarly, the return periods of 6, 12 and 24-hour half-value rainfall amounts of 2006 disaster are 4, 5 and 9 years, respectively. The 12-hour half-life rainfall amounts have in-between values of return period for both 2003 and 2006 years among the 6, 12 and 24-hour half-value modified rainfall amounts (Table 2.7.1). As 12-hour half-value modified rainfall has in-between value of return period, it can be used effectively for early warning of disasters which occur due to high intensity rainfall as well as gentle and long duration rainfall. Therefore, 12-hour half-value modified rainfall amount is decided to use as threshold value in early warning for traffic control and residents evacuation on the N-M Highway.

Table 2.7.1 Return Periods of Each Type of Rainfall Amounts

Year	Date	Maximum of 24-hour Rainfall Amount mm (yr)	Maximum of 6-hour half-value Rainfall Amount mm (yr)	Maximum of 12-hour half-value Rainfall Amount mm (yr)	Maximum of 24-hour half-value Rainfall Amount mm (yr)
1998	5-Jul	162.3 (1)	31 (1)	60.2 (1)	118.8 (1)
1999	25-Aug	250 (3)	47.7 (2)	92.8 (2)	182.9 (3)
2000	24-May	131 (1)	25 (1)	48.6 (1)	95.9 (1)
2001	30-Jul	224.9 (2)	42.9 (2)	83.5 (2)	164.6 (2)
2002	12-Jul	180.2 (2)	34.4 (2)	66.9 (2)	131.9 (2)
2003	31-Jul	446.2 (16)	224 (85)	303 (58)	362 (25)
2004	3-Sep	152.3 (1)	29.1 (1)	56.5 (1)	111.4 (1)
2005	7-Aug	100.3 (1)	19.1 (1)	37.2 (1)	73.4 (1)
2006	9-Sep	376.4 (9)	71.8 (4)	139.7 (5)	275.4 (9)

Note: Values in parentheses indicate return periods

2.7.4 Early Warning System Development

The early warning system should be developed for minimizing the loss of properties and lives from rainfall triggered disasters on the highway and villages. Therefore, two separate early warning criteria are proposed for traffic control on the highway and for evacuation of village residents.

2.7.5 Early Warning Criteria for the Highway

Three Warning Levels are proposed based on the 12-hour half-value rainfall amount for traffic control on the highway (Figure 2.7.4). Because, the use of H-hour half value modified rainfall amount instead of accumulated rainfall amount for early warning purposes increases the reliability of early warning against the rainfall triggered disasters.

Level – Care: This level will be issued to start monitoring of rainfall hourly on standby position by concerned agencies on heavy rainfall days. If 12-hour half-value modified rainfall amount becomes more than 80 mm (2-year return period) then this level-care will be issued.

Level – Caution: This level will be issued to alert the vehicle drivers on possibility of happening rainfall triggered disasters like rock fall and landslide on the highway; and to suggest the drivers for careful driving on the highway. If 12-hour half-value rainfall amount becomes more than 140 mm (5-year return period) then this warning level-caution will be issued.

Level – Warning: This level will be issued to close the highway due to being almost sure for happening rock fall, landslides and debris flow disasters on the highway because of extremely high rainfall. If 12-hour half value rainfall amount becomes more than 180 mm (10-year return period) then this level-warning will be issued.

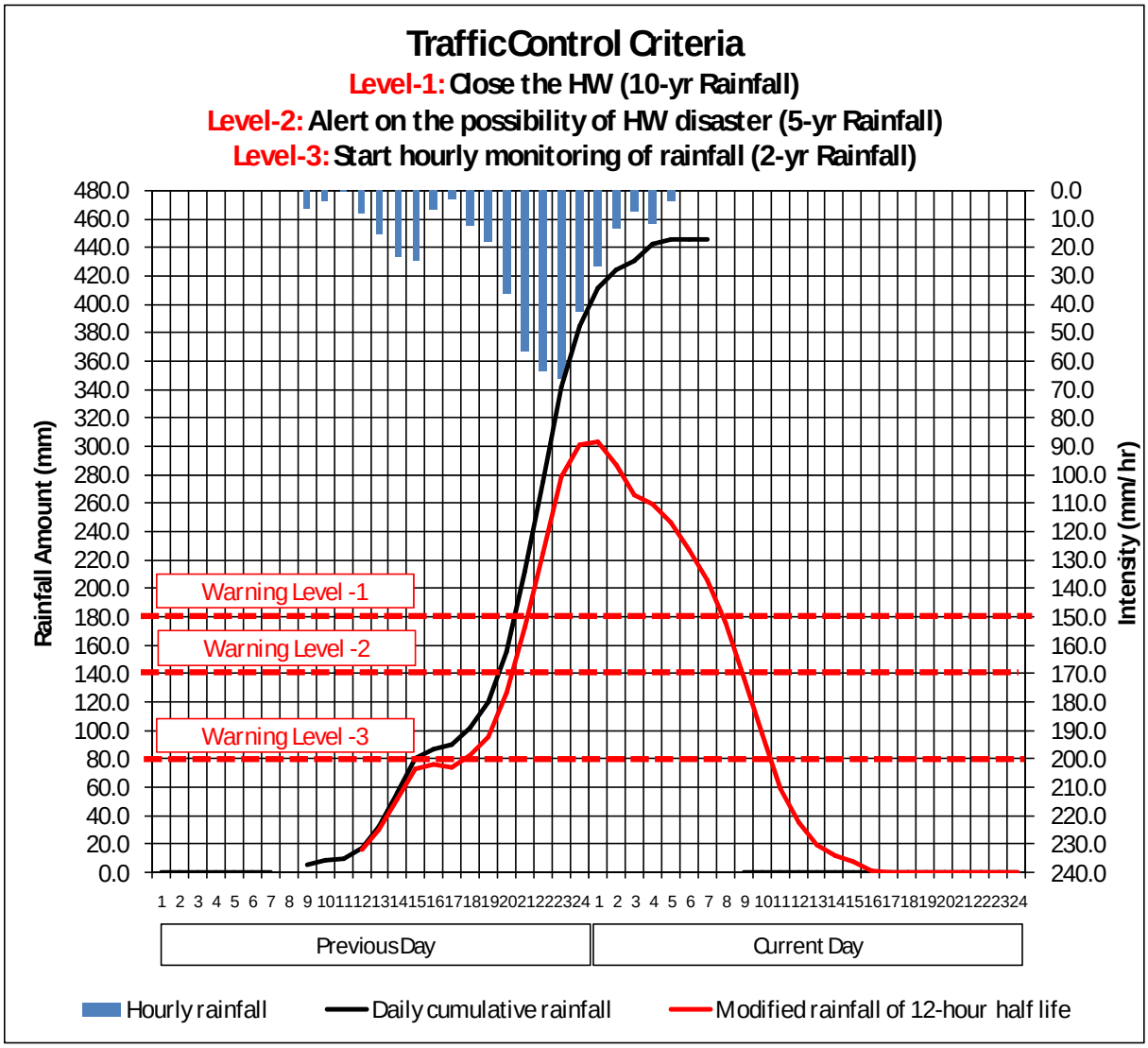

Figure 2.7.4 Warning Levels for Traffic Control on the Highway

2.7.6 Early Warning Criteria for Residents Evacuation

Warning on possibility of happening landslide and debris flow disasters in villages should be given in advance with sufficient lag time for evacuation. Therefore, early warning on possibility of happening disaster in villages is most important to save people lives and their properties. For early warning purposes, each ward chairman of village should be informed from the VDC office through CDMA phone. The threshold values of rainfall for warning and evacuation of village residents would be slightly lower than that of traffic control on the highway for the safety of residents in villages. The residents of landslide and debris flow prone villages, especially the village's ward chairman, should be advised to be in-touch

continuous with VDC office/ DRO/ DPO on heavy rainfall days and follow the instruction provided by them. Three Levels are proposed based on the 12-hour half-value rainfall amount for residents evacuation from villages for their safety (Figure 2.7.5).

Level – Care: This level will be issued to alarm villagers to pack up their daily usage goods and valuables; and to start monitoring of the rainfall hourly by the assigned persons. If 12-hour half-value rainfall amount becomes more than 60 mm (1-year return period) then this level-care will be issued.

Level – Caution: This level will be issued to prepare villagers for evacuation altogether with their daily usage goods and valuables; to keep them in standby position; and to alert them on possibility of happening water-induced disasters. If 12-hour half-value rainfall amount becomes more than 80 mm (2-year return period) then this level-caution will be issued.

Level – Warning: This level will be issued to evacuate villagers to the safer place due to being very high possibility of happening water-induced disasters in the village because of heavy rainfall. If 12-hour half-value modified rainfall amount becomes more than 140 mm (5-year return period) then this warning level will be issued.

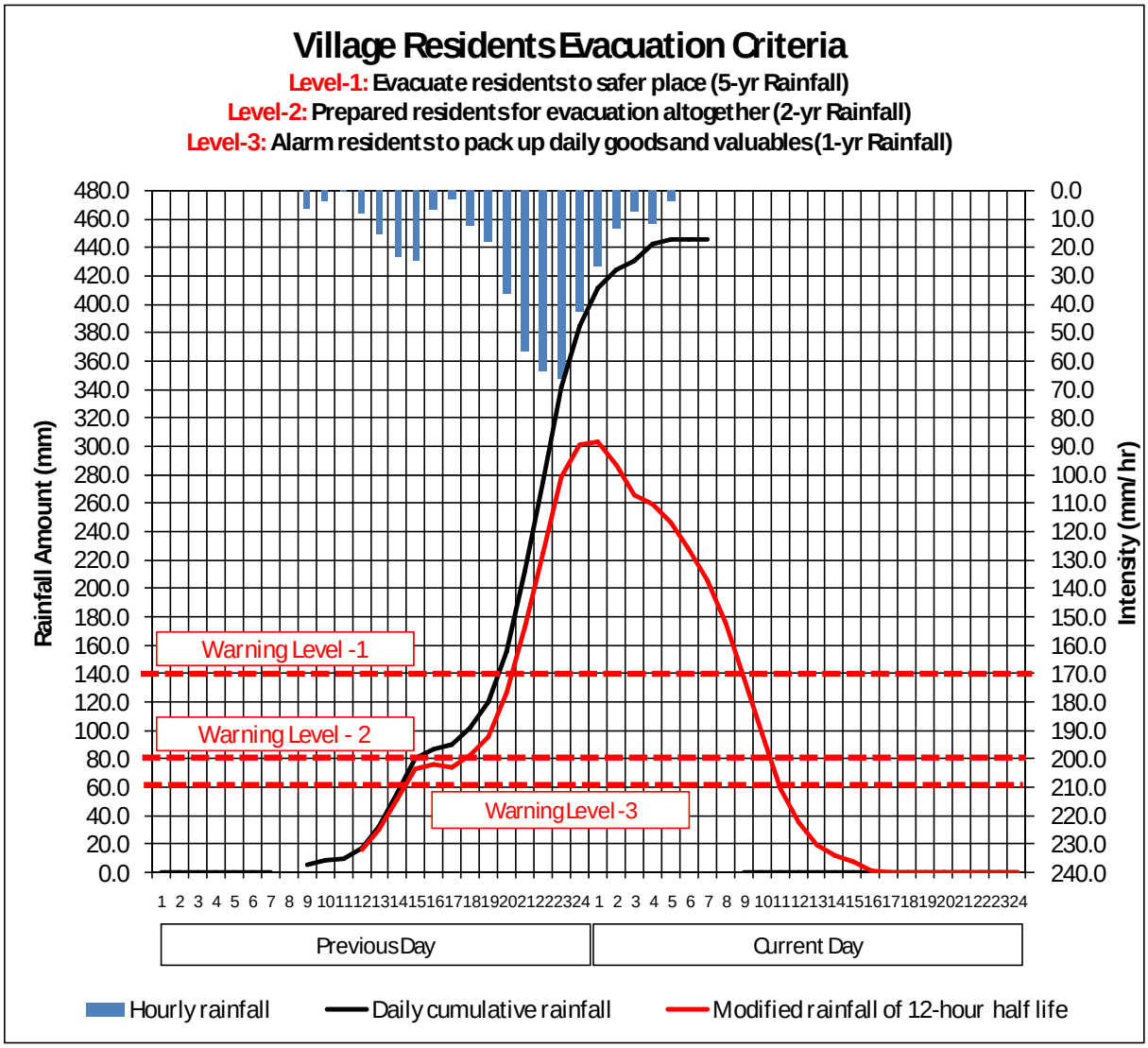

Figure 2.7.5 Warning Levels for Village Residents Evacuation

2.7.7 Proposed Rainfall Monitoring Stations on the Highway

Four manual and two automatic rainfall monitoring stations are proposed along the Narayangharh-Mugling Highway for effective early warning system development to alleviate the water-induced disaster on the highway and villages (Figure 2.75). The automatic rain-gauge is proposed to install at Jugedi for real-time rainfall data acquisition for early warning system development. Locations of the proposed rainfall monitoring stations along the highway are: (1) Bharatpur (District Road Office, at 0 km from Narayangharh) (2) Jugedi (Kabilas VDC office compound, at 10 km from Narayangharh), (3) Kahale Kola (existing manual rain gauge monitoring site, at 11 km 300m from Narayangharh), (4) Gaighat (at18 km from Narayangharh) and (5) Paireni (at 31 km from Narayangharh). The automatic

on-line rainfall station accompanied by manual rainfall stations at the proposed sites would help greatly on development of an effective early warning system of disasters on the highway and villages. Although, manual rainfall stations will not be much effective for warning system as compared to automatic on-line station; but manual rainfall stations could be used in early warning if some problem occurred in automatic on-line station, so it makes the warning system sustainable.

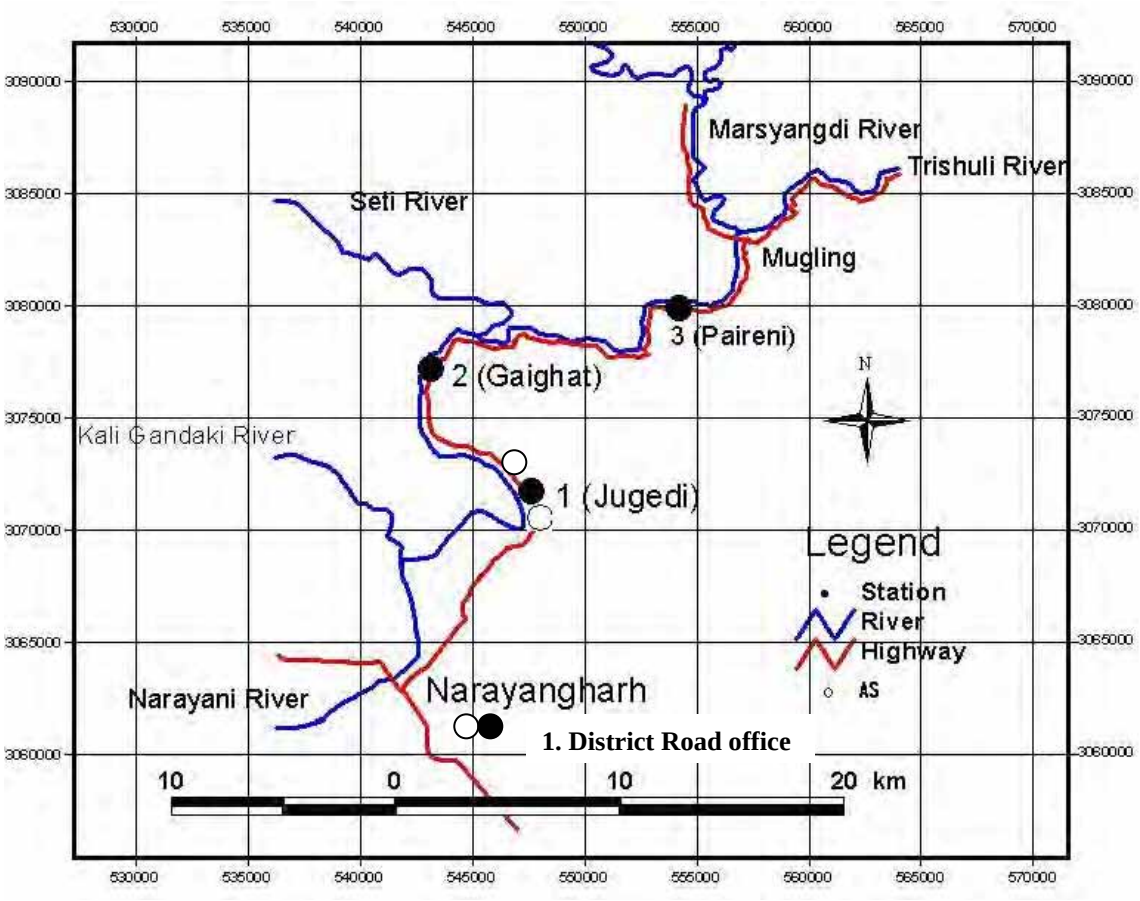

Figure 2.7.6 Proposed Sites of Rainfall Monitoring Stations

2.7.8 Traffic Control and Evacuation Information System

The Divisional Road Office (DRO), Bharatpur should monitor hourly rainfall during heavy rainfall days and should check the criteria of warning levels based on the 12-hour half life modified rainfall amount. The DRO should monitor real-time rainfall from the automatic rain-gauge. The DRO should inform the situation of rainfall and warning level to be issued to District Police Office (DPO). The DRO should also inform on the situation of rainfall and warning level to Kabilas VDC office. Under the coordination of the Chief District Officer (CDO), the activities like traffic control on the highway and evacuation of village residents

should be carried (Fig. 6.23). Traffic control on the highway should be carried out by the police offices at Mugling and Anptari under the instruction of DPO. The DPO should also coordinate to display message of traffic conditions and warning levels for possibility of rainfall triggered disaster on the highway on notice boards at Mugling and Anptari. Similarly, the rescue operation when needed should also be launched under the coordination of CDO. All the concern agencies for rescue operation should be immediately informed to remain in standby position when warning level -1 is issued. The traffic police should take action based on the warning levels and divert the traffics from Naubise, Mugling and Aanptari suggesting drivers to use alternate highways.

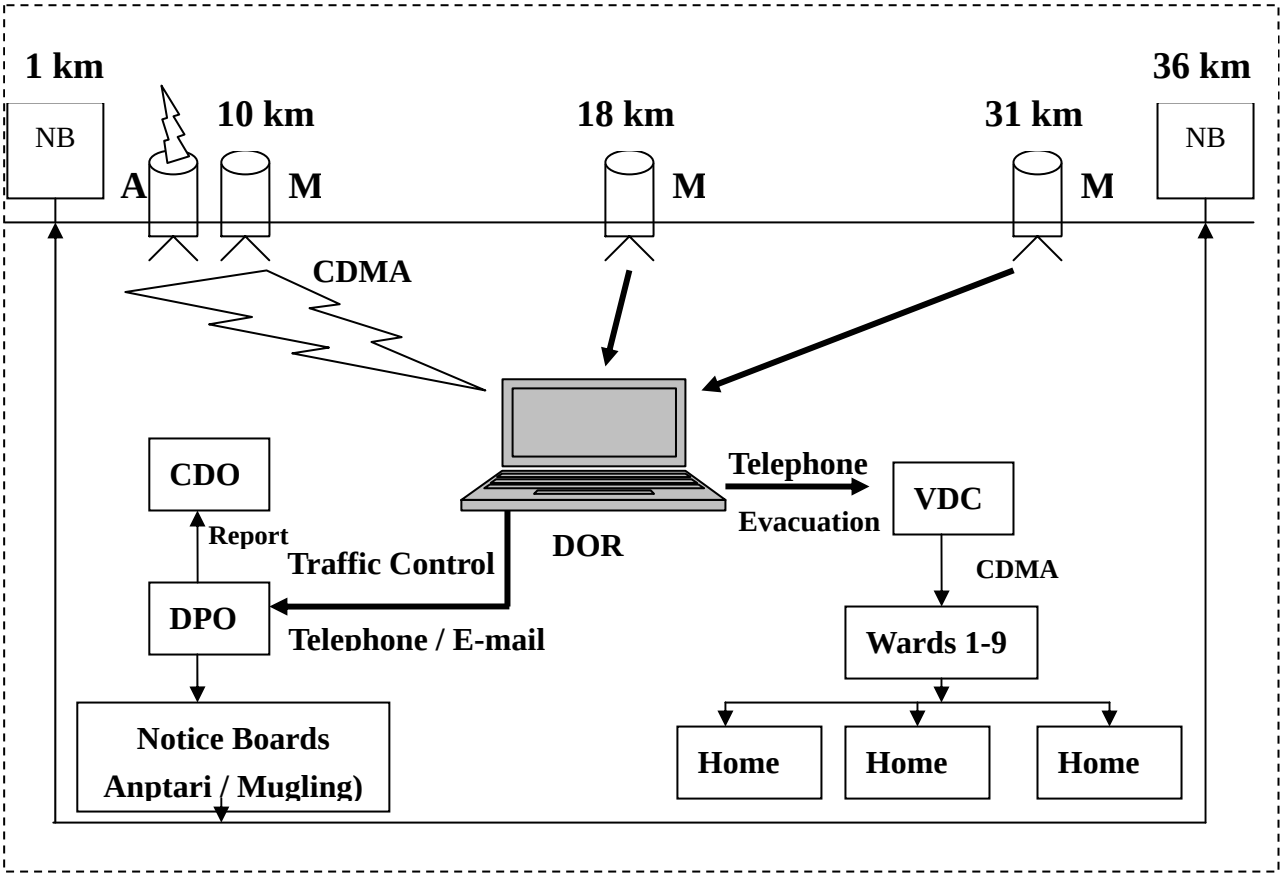

Fig. 2.7.7 Traffic Control and Evacuation Information System

2.7.9 Highway Traffic Condition Notice Display Boards

The highway traffic condition notice display boards should be installed along the main cities of national highway network to avert the unnecessary troubles to travellers. If some problem occurred along the Nayarangharh-Mugling Highway, notice of the traffic problem on the

highway should be displayed at major origin cities and national highways bifurcation points like Nagdhunga, Naubesi, Birgunj, Hetauda, Narayangharh, Mugling, Pokhara, Butwal and Bhairahawa (Fig. 6.24).

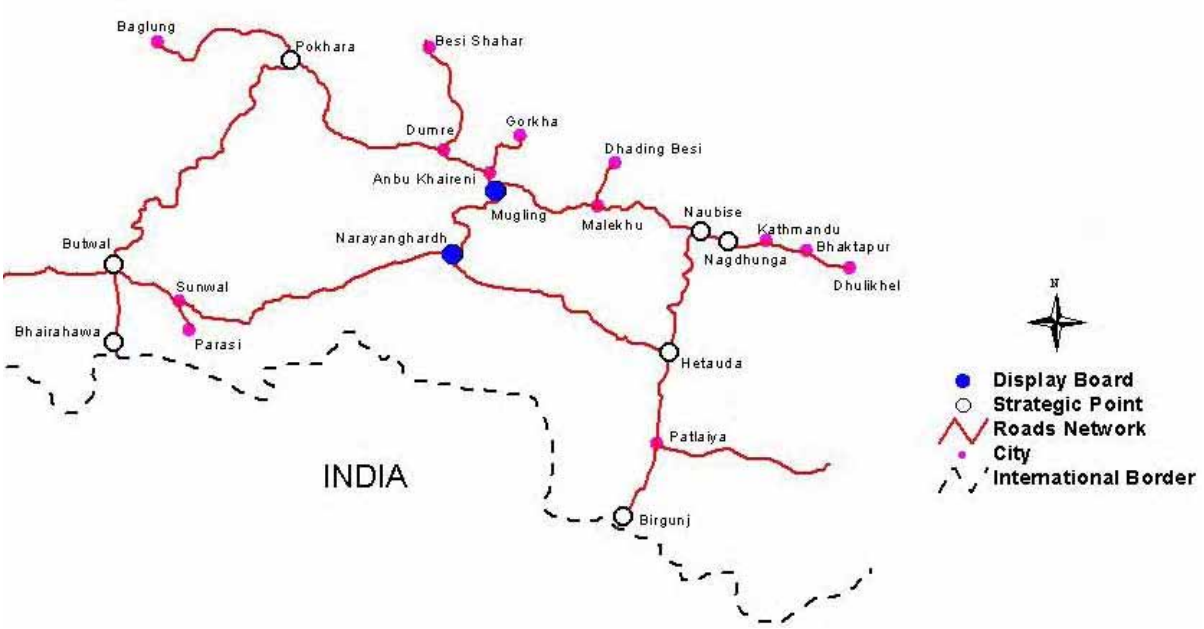

Fig. 2.7.8 Proposed Sites for Highway Traffic Condition Notice Board

2.7.10 Recommendations for Rainfall Monitoring

At present there is only one non-recording rainfall station at Khahare Khola (at 11 km from Narayangharh) on the Narayangharh-Mugling Highway. Only one non-recording station on the highway is not sufficient to monitor the rainfall for developing warning system to avert highway disasters. Hence, following conclusions are drawn for rainfall monitoring on the highway for effective road disasters early warning system development.

- Meteorological radar should be installed at Manakamana, Gorkha to monitor real time meteorological conditions and to forecast rainfall precisely with enough lag time to avert highway disasters. This radar could be used for rainfall monitoring and forecasting not only along the Narayangharh-Mugling Highway but also along the Prithwi Highway (Kathmandu-Pokhara), Aanbu Khaireni-Gorkha Highway and Tribhuvan Highway (Kathmandu-Birgunj). Therefore, meteorological radar at this place could be of great importance for averting the highway disasters in Nepal.
- To develop an effective disaster warning system along the Narayangharh-Mugling Highway, rainfall should be monitored with installing at least one automatic rain-gauge (at Jugedi) and three manual rain-gauges at Jugedi (Kabilas VDC office

compound), Gaighat (18 km from Narayangharh), and Paireni (31 km from Narayangharh) on the highway. The automatic rain-gauge gives real time rainfall data so it makes easier on decision making for early warning.

- Automatic rain-gauge should be accompanied by manual rain-gauges for monitoring rainfall continuously even some problems occurred in automatic station. Inclusion of manual rain-gauges makes the warning system sustainable and maintains continuity in rainfall records.
- For early warning to residents in villages on landslide and debris flow disaster, each ward of village should be equipped with a CDMA phone and villagers should advise to get information on rainfall and warning level from the DRO/DPO/VDC on heavy rainfall days.

APPENDIX

Appendix 1 Maximum 1-day Rainfall at Devghat Station

S. N.	Year	Date	Rainfall (mm)
1	1998	5 July	162.3
2	1999	25 August	250.0
3	2000	24 May	131.0
4	2001	30 July	224.9
5	2002	12 July	180.2
6	2003	31 July	446.3
7	2004	3 September	152.3
8	2005	7 August	100.3
9	2006	9 September	376.4

Appendix 2 Maximum 2-day Rainfall at Devghat Station

S. N.	Year	Date	Rainfall (mm)	2-day Rainfall (mm)
1	1998	20 June	128.0	216.3
		21 June	88.3	
2	1999	25 August	250.0	300.2
		26 August	50.2	
3	2000	23 June	78.0	175.4
		24 June	97.4	
4	2001	30 July	224.9	325.6
		31 July	100.7	
5	2002	11 July	33.2	213.4
		12 July	180.2	
6	2003	31 July	446.2	517.8
		1 August	71.6	
7	2004	3 September	152.3	214.8
		4 September	62.5	
8	2005	6 August	54.3	154.6
		7 August	100.3	
9	2006	9 September	376.4	666.0
		10 September	289.6	

Appendix 3 Maximum 3-day Rainfall at Devghat Station

S. N.	Year	Date	Rainfall (mm)	3-day Rainfall (mm)
1	1998	4 July	44.5	255.5
		5 July	162.3	
		6 July	48.7	
2	1999	25 August	250.0	332.5
		26 August	50.2	
		27 August	32.3	
3	2000	23 June	78.0	208.3
		24 June	97.4	
		25 June	32.9	
4	2001	30 July	224.9	445.8
		31 July	100.7	
		1 August	120.2	
5	2002	12 July	180.2	335.5
		13 July	0.0	
		14 July	155.3	
6	2003	30 July	39.8	557.6
		31 July	446.2	
		1 August	71.6	
7	2004	2 September	43.7	258.5
		3 September	152.3	
		4 September	62.5	
8	2005	6 August	54.3	186.3
		7 August	100.3	
		8 August	31.7	
9	2006	9 September	376.4	690.5
		10 September	289.6	
		11 September	24.5	

III

ACTIVITIES FOR ROAD SLOPE DISASTER MANAGEMENT IN DWIDP AND DOR

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III.

ACTIVITIES FOR ROAD SLOPE DISASTER MANAGEMENT IN DWIDP AND DOR

3.1 Disaster Management in National Level

In general Nepal is highly prone to various types of disasters but water induced disasters is the major one. Each year approximately one thousand people are killed, about one hundred people get lost and thousands of families are exposed to heart breaking situation due to disasters. In addition, property worth of millions is alsoruined. To cope with such natural disaster, the disaster management system has been formulated in national level.

3.1.1 Institutional Arrangements for Natural Disaster Relief

The Natural Disaster Relief Act (NDRA) has been established to constitute the organizational structure through which the various activities of disaster management are being carried out effectively and efficiently. Functions and roles of each committee are designated as presented in the Table 3.1.1.and Organization structure of various relief committees is presented in the Figure 3.1.1.

Table 3.1.1 Roles and Functions of Committees

Name of Committee	Roles and Functions
1. Central Natural Disaster Relief Committee	(Constituted under the Chairperson of Home Minister) a) Formulate and implement the policies and programs regarding natural disaster relief work b) Undertake necessary measures related disasters c) Prepare specific norms for relief assistance in cash and kind d) Distribute to disaster victims
2. Relief and Treatment Sub- Committee 3. Regional Natural Disaster Relief Committee 4. Supply, Shelter and Rehabilitation Sub-Committee	Provide necessary advice and suggestions to the central committee to execute policies and directives for rescue operation
5. District Natural Disaster Relief Committee 6. Local Natural Disaster Relief Committee	a) Keep records of disaster affected areas and victims b) Carry out rescue and rehabilitation works for the victims at local levels in cooperation with other disaster related agencies.

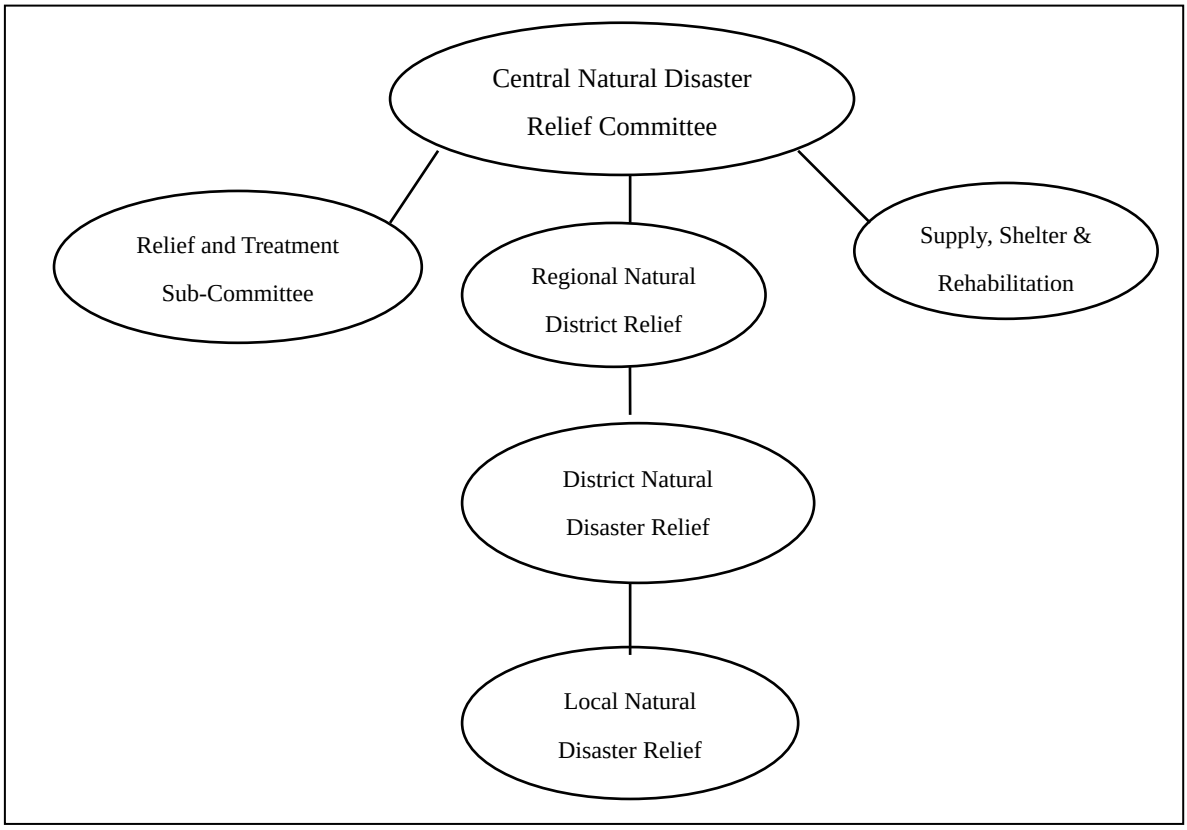

Figure 3.1.1 Organization Structure for Natural Disaster Management in Nepal

(Source: Mitigation and Management of Floods in Nepal, 2001)

3.1.2 National Action Plan on Disaster Management

A "National Action Plan on Disaster Management" has been prepared by Government of Nepal. The major programs and activities on disaster preparedness, response, reconstruction, and mitigation action plan have been formulated as follows in 2001. For the preparation of this Plan almost all Ministries of the Nepal Government are involved.

(1) Measures related Geological, Hydrological and Metrological Hazard Assessment

(Executing organization**:** MOFSC, TU, DWIDP, and DMG)

Activity

1. Landslide hazard assessment
2. Landslides hazard mapping of selected areas
   a) Identify priority areas
   b) Establish standard for landslide hazard mapping
   c) Assess existing data on landslides

d) Introduce remote sensing techniques for landslide detection

e) collect, compile, produce and disseminate landslide hazard maps and records

3. Planned engineering and environmental studies and mapping
4. Hydrological metrological hazard studies
5. Preparation of flood hazard and debris flows hazard maps
6. Preparation of glacial lake location map and rainfall intensity map.
7. Establishment of flood forecasting and warning systems
8. Improvement of hydro-metrological observation network
9. Collect, compile and disseminate flood hazard maps

(2) Awareness Raising Programs

(Executing organization**:** MOIC and MOHA)

Activity

1. Raising awareness through mass media
2. Distribution of pamphlets, posters and other materials
3. Preparation of documentary film, slides for public show
4. Inclusion of disaster management course in secondary school syllabus
5. Poetry, debate and essay competition
6. Regional workshop and national conference

(3) Training/Rehearsals/Simulations

(Executing organization**:** NRCS, MOHA, Local NGOs)

Activity

1. Community leaders training programs at local levels
2. Training on disaster management at various level

3 Conduct rehearsals and simulations in vulnerable areas

(4) Disaster Management Information System

(Executing organization**:** MOIC, NA, Police, INGOs, NGOs)

Activity

1. Establish and maintain a communication system in all 75 districts with access to centre
2. Encourage, support and expand local communication practices
3. Establish a National Disaster Management Information System for disaster information collection and dissemination.

(5) National Land Use and Cover Plan

(Executing organization**:** MOFSC, MOWR)

Activity: Formulation and Implementation of National Land Use and Land Cover Plan

(6) Policy on Disaster Reduction Measures

(Executing organization: MOFSC, MOWR)

Activity: Formulation of disaster reduction programs

(7) Promotion of Regional and Sub-regional Cooperation between Countries exposed to same Natural Hazards

(Executing organization**:** MOFA, MOWR, and MOI)

Activity:

1. Set-up bilateral or multilateral joint committees on disaster reduction
2. Exchange information and shares experiences for disaster reduction issues
3. Implement disaster reduction strategies

(8) Establishment of Documentation Centre on Disaster Management

(Executing organization**:** MOFA, MOWR, and MOI)

Activity: Establish documentation centre for compiling, collecting, publishing and disseminating information on disaster management

3.1.3 Strategic Response National Policy Framework

The Ministry of Home Affairs is main coordinator of disaster management in Nepal. The Ministry formulates and manages national policies and their implementation, preparedness and mitigation of disasters, immediate rescue and relief works, data collection and dissemination, collection and distribution of funds and resources are main functions.

Chief District Officer (CDO) of 75 districts acts as the crisis manager at the time of natural disaster.

(1) Tenth Plan 2003-2008

- Plan has identified natural and human induced disaster management as the core need of sustainable and broad based economic growth
- Plan has adopted policy on disaster risk reduction in Nepal
- Plan has included preparedness activities for disaster management at national and community levels
- Plan provides local bodies, NGOs, community organizations and the private sector opportunity for preparedness actions including rescue and relief.
- Integrated the objective of : (a) making development and construction works sustainable, reliable and effective (b) mitigating disasters to secure life of common people through appropriate strategies and programs

(2) Operating Strategies for Disaster Risk Reduction and Disaster Management

- Carry out rescue and relief works in disaster affected areas
- Protect and reduce the loss of life and property and mitigate the suffering of people
- Implement effective land use zoning, prepare hazard maps of the disaster prone areas
- Raise disaster awareness to the people and provide training at community level for effective disaster management
- Coordinate different stakeholders involved in disaster management and proper mobilization of non-governmental organizations in rescue and relief works
- Mobilize internal and external resources for rehabilitation and reconstruction
- Formation of teams and their mobilization in disaster areas to assist in relief works
- Assess the damages, collect and analyze data, and disseminate information

3.1.4 Other Agencies Contributing Natural Disaster Management

The following governmental and non-governmental agencies are involved in disaster prevention and mitigation works in Nepal.

World Bank, Asian Development Bank, Japan International Cooperation Agency (JICA), Asian Disaster Reduction Centre (ADRC), Asian Disaster Preparedness Centre (ADPC), United Nations Development Program (UNDP), International Centre for Integrated Mountain Development (ICIMOD), International Red Cross Society (IRCS),United States Agency for International Development Mission to Nepal (USAIDM-N),United Mission to Nepal (UMN), Cooperation for American Relief Everywhere (CARE), World Food Programme (WFP),Save the Children Fund (SCF), Technical Cooperation of the Federal Republic of Germany (GTZ), Lutheran World Services (LWS)

In addition, various professionals of government and non-government organizations in Nepal are also providing highly valuable supports at the time of disasters.

The Government of Nepal is becoming aware of the need for the empowerment of the younger generation to combat disasters. Therefore, Disaster Mitigation education was one of the main activities of the DMSP.

3.2 Activity of DWIDP on Sediment- Related Disaster

DWIDP was established in 1991 as the Water Induced Disaster Prevention Technical Centre (DPTC), under the Ministry of Water Resources as the lead agency. Now it is a department of Government of Nepal. The Government of Japan through JICA has been assisting to promote the capacity of Government of Nepal and the communities to cope with water induced disasters. The Disaster Mitigation Support Program Project (DMSP) through JICA cooperation was an attempt to manage these water induced disasters in a comprehensive manner with community involvement through model mitigation works.

3.2.1 Organization of DWIDP

(1) Organization of DWIDP

The organizational structure of DWIDP is presented in Figure 3.2.1. It is composed of two division and six sections under the Director General which job description is shown in the Table 3.2.1.

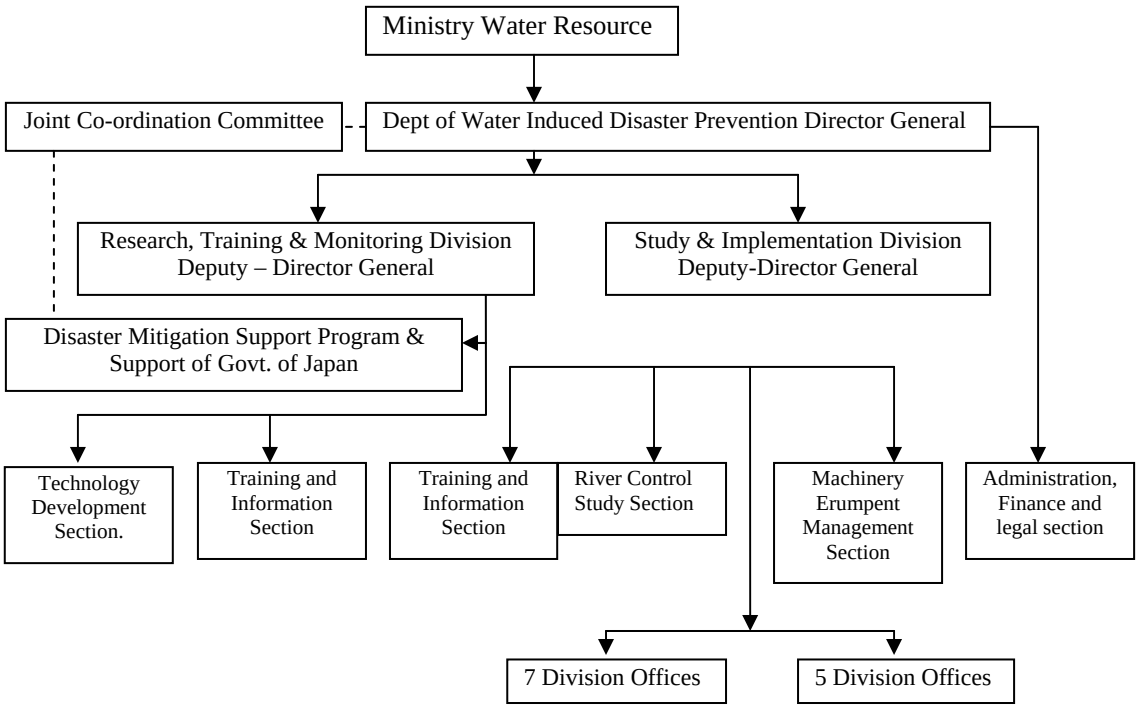

Figure 3.2.1 Organization Chart of DWIDP

Table 3.2.1 Job Descriptions of Sections under DWIDP

Name of Sections	Job Descriptions
Technology Development Sections	1. Develop sustainable and environment feasible technologies in combination with local knowledge and modern techniques to reduce water induced disasters 2. Implement pilot project on suitable location on landslides, soil erosions and river management 3. Rehabilitate to the victims for water induced disasters as landslides, floods etc 4. Provide necessary advice to water induced 5. disaster management related organizations to reduce disaster 6. Carry out other necessary activities
Training and Information Section	1. Based on needs identification and analysisstrengthen the professional capabilities of concerned organizations of Nepal by conducting training , classes, practice, site observations in regard to reduction of water induced disasters. 2. Collect information and develop information systems on metrology, geology, water induced disasters and rehabilitation. 3. Conduct seminars, workshops, interactions programs at national and international levels and publish related documents 4. Conduct necessary activities
River Control and Study Section	1. Conduct survey of national rivers forpurpose ofriver control management 2. Formulate planning, design, selection and implementation for river control management 3. Prepare and update manuals of norms and criteria for river control 4. Coordinate on study on river control conducted by others offices 5. Maintain update records of studies on river control 6. Prepare proposals on new projects on river control management 7. Collect, document and store necessary information on river control management 8. Prepare necessary programs and budgets for Section. 9. Conduct others necessary activities
River Control Implementation Section	1. Approve projects prepared by Divisions, Sub- Divisions and Planning Sections 2. Approve projects by examining and verification in detail of survey, design and costs 3. Conduct workshops on trial of river models, water logging, policy formulation and approve projects by analyzing detail costs 4. Manage and utilize the materials received by grants and donation 5. Monitoring and supervision of quality of projects implemented under Divisions and Sub-Divisions 6. Conduct others necessary activities
Machinery Management Section	1. Repair, maintenance and utilize of machinery and equipment under DWIDP 2. Prepare necessary policy and program for machinery management 3. Maintain and update records of machinery under DWIDP 4. Formulate necessary budget for management of machinery 5. Train potential manpower for efficient utilization of machinery 6. Determine rates of lease of machinery 7. Assist to Division and Sub-Divisions on machinery 8. Conduct necessary activities

3.2.2 Main Activities and Projects of DWIDP

Following three themes are the major activities to contribute mitigation and reduction of water induced disaster in Nepal. (Source: DWIDP, an Introduction)

(1) Main Activities

(a) Technology Development Work

The main activity under this work is to develop the environment friendly technology by amalgamation of local and modern technology. Various technologies are prepared proposed and compared in the selected sites appropriate technology suitable to specific site. The disseminated through technical guidelines and providing suggestions to on going projects.

(b) Training, Study and Introduction Work

Trainings are conducted to develop the knowledge and skills of the technical staffs of Government offices and related agencies associated with water- induced disaster mitigation works. A data bank is established by collecting information related to water induced disasters and these information are disseminated through various publications. Beside these, various studies on water-induced disasters are performed Community awareness programs are conducted through seminars and workshop.

(c) Water Induced Disaster Mitigation Work

Emergency works, point control works and long-term mitigation works through the preparation of master plans are implemented against the water induced disasters such as flood, landslide & debris flows under this activity.

(2) Programs and Projects

(a) Disaster Mitigation Support Program
(b) River Training Project
(c) Mugling-Narayanghat Water Induced Disaster Prevention Project
(d) bagmati River Training project
(e) Lal Bakaiya River Training Project
(f) Sindhuli-bardibas Water Induced Disaster prevention Project

3.2.3 Manpower of DWIDP

Activities mentioned in the former clause are carried out by human resources of total 231 which are shown in the Table 3.2.2. (Source: DWIDP, an Introduction)

Table 3.2.2 Manpower of DWIDP

Unit	GI	GII	GIII	NG I	NGII	NC	Total
Department	3	7	24	29	2	5	70
Division	-	7	22	58	9	30	126
Subdivision	-	-	5	10	10	10	35
	3	14	51	148	21	45	231

G: Gazetted, NG: Non-Gazetted, NC: Non-classified

3.2.4 Environmental Management DWIDP

DWIDP has developed river training master plans for Kankai and Chisang rivers. It also undertakes research and technology development on landslide management and river training. It has also undertaken water induced hazard mapping and capacity building of government staff and local stakeholders.

Though DWIDP's work is related to environment – such as river training, bioengineering, slope stabilization and treatment – it does not have a specific environment related unit. DWIDP has no legal mandate to make preemptive moves to stop environmental degradation, induced natural hazards due to activities such as badly planned and implemented mining activities. DWIDP's mandate also overlaps that of other regular maintenance programs of other govt. infrastructure programs.

DWIDP has supported conservation of infrastructure such as for the Middle-Marsyangdi access road in coordination with DOR. DWIDP was responsible for river training to protect vulnerable land below the road, and for bioengineering, slope treatment & stabilization and check-dams constructions above the road. Similarly, DWIDP has also supported bioengineering work along the Banepa-Bardibas and Narayangharh-Muglin roads section. DWIDP has also implemented river control projects carried with support from the Indian government - particularly for the Bagmati river, Lal Bagiya River and Kamala river. DWIDP is also implementing the Disaster Mitigation Support Programme Project (DMSP) with support from the Japanese Government. So far, DWIDP has only undertaken one IEE for Kamala river training work.

3.3 Organization of DOR

3.3.1 Regular Funding Sources for Road Maintenance

Organization chart Organization of DOR is presented in the Figure 3.3.1.

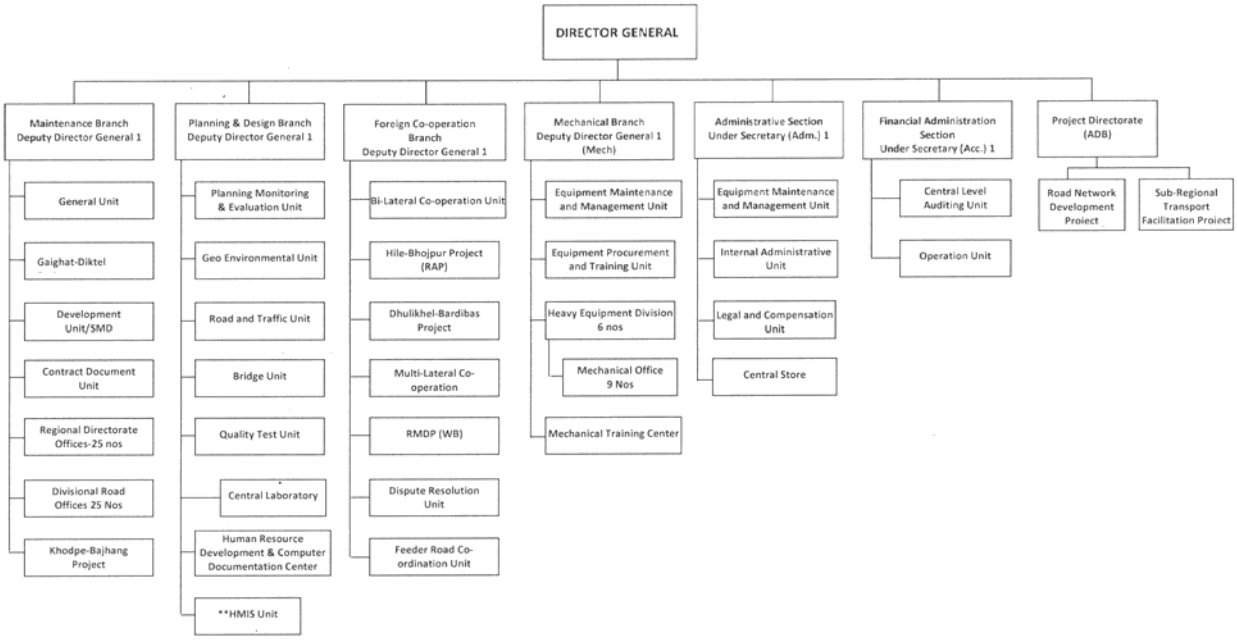

Figure 3.3.1 Organization of DOR

DoR composed of major five Technical branches, Administrative Section and Financial Administration Section. Main functions and roles of each branch is as follows.

(1) Maintenance Branch

- Carry out day to day general administrative works of Maintenance Branch
- Carry out regular maintenance activities of different road projects
- Prepare contract documents for clients for maintenance works
- Supervise the maintenance activities of 25 Divisional Offices in 5 Regions
- Test and control of quality of materials and construction of works
- Supervision of contract works
- Prepare Annual Road Maintenance Plan
- Maintain updated auditing
- Maintain update records and security of machines, equipment and other assets under Maintenance Branch
- Carry out evaluation of work performances of staff under branch

(2) Planning and Design Branch

- Prepare policy and programs of road development
- Prepare design of roads in collaboration with national and international clients and consultants
- Approve plans and designs prepared by clients and consultants
- Carry out monitoring and evaluation of planning and design of roads
- Prepare performance evaluation reports on road development
- Train necessary manpower, maintain documentation and information centre and disseminate information

(3) Foreign Co-operation Branch

- Coordinate with bi-lateral and multi-lateral international funding and donor agencies for road development projects
- Prepare road development proposals
- Prepare contract and agreement with international donor and funding agencies
- Evaluate performance of foreign projects
- Dispute resolution in any foreign funded project
- Coordinate with feeder road projects in their planning and management

(4) Mechanical Branch

- Repair and maintenance of equipment
- Support Division Road Offices and projects for operation of equipment
- Supervise in operation of equipment of six Heavy Equipment Divisions and nine Mechanical Offices
- Procure equipment for Division Road Offices, Mechanical Offices and Training Centre
- Conduct Mechanical Training Centre in Lalitpur, Kathmandu

(5) Administrative Section

- Carry out daily administrative duties of Road
- Determine numbers of necessary manpower needed for DOR
- Arrange transfer, promotion, appointment, rewards and punishment for staff of DOR
- Arrange work performance appraisal of DOR staff
- Maintain updated records and files of staff of DOR
- To ensure that assigned works are carried out in accordance with all Government prevailing Acts and Rules and Regulations
- Maintain security and cleanness of office and office compounds, conduct regular supervision and keep safety of office assets
- Manage complain box and make process on decision making of complains

- Formulate policies, rules and regulations of DOR in consultation with branches of DOR
- Maintain and operate store of DOR

(6) Financial Administration Section

- Prepare for annual budget
- Arrange expenditures for approved budget
- Maintain updated records financial transactions
- Arrange auditing functions

(7) Project Directorate

- Supervision and management of road network development operated under Asian Development Bank Project
- Coordinate with concerned agencies in planning, supervision and management of transport facilitation projects funded under Asian Development Bank at sub-regional level.

Among five technical branches, the Maintenance Branch is responsible for comprehensive road maintenance works.

3.3.2 Activities for Road Maintenance Work of DRO, Baharatpur, Chitwan

Division Road Office, Bharatpur is responsible for disaster management and maintenance of strategic roads in Chitwan and Dhading districts of Nepal. These roads are comprised of 186 km of National Highways and 23km of feeder roads. In addition to this, the Division is also involved in construction of major bridges within these two districts.

(1) Organization of Division Office Bahratpur, Chitwan

Narayangarh-Mugling Highway lies under the supervision and maintenance of Division Road Office in Bharatpur, Chitwan district. Under the Technical Section, Division Office, Bharatpur, 4 Engineers, 12 sub Engineers, 5 Drivers Operators, 1 Lab Technician and 2 Lab boys have been employed on permanent basis. In addition, 11 Supervisors and 75 Length workers have been deployed on temporary basis. In case of urgent disaster, equipment from other offices such as Hetauda, Janakpur, Naubishe and Gajuri have been used in disaster sites within Narayangarh-Mugling Highway.

The organizational chart of Division of Road, Project Office in Chitwan is presented in Figure 3.3.2

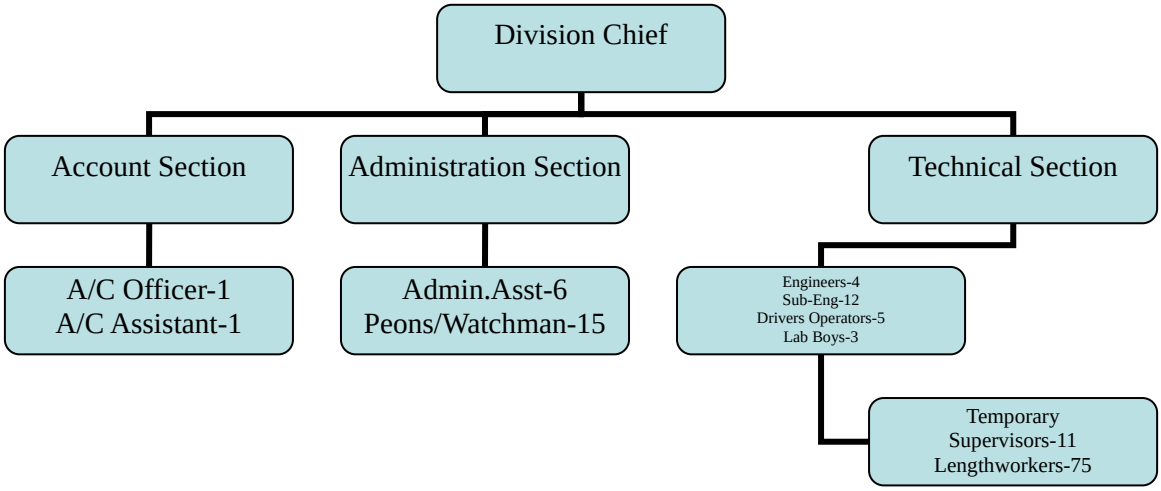

Figure 3.3.2 Organization Chart of Division of Road, Chitwan

(2) Routine Maintenance

Total 75 length workers are employed in Chitwan district and each worker is assigned a section of road and will be responsible for the routine maintenance. At the beginning of fiscal year, agreement of each length worker will be updated for the period of one year. A site of mechanical office with 3 loader machines is responsible for routine maintenance of Mugling -Narayangarh Highway. However, considering the nature of urgency, the required number of operators and machines will be deployed in site from other Civil Division Offices situated in Hetauda, Janakpur and Bharatpur.

(3) Response on Urgent Disaster and Reopening

As mentioned in above (2) in order to response on urgent disaster and reopening considering the nature of urgency, the required number of operators and machines will be deployed in disaster sites from the Division offices Hetauda, Janakpur and Bharatpur. Currently, the road maintenance sites are located in Mugling, Naubise and Gajuri. Currently, in Technical Section of the Road Division office, Bharatpur, 4 Engineers, 12 Sub-engineers,5 Drivers Operators, 1 Lab Technicians and 2 Lab boys are working on permanent basis. In addition, 11 Supervisors and 75 Length workers are working as temporary. The manpower will be responsible to look after Chitwan and Dhading districts.

However, Yearly Emergency Action Plan will be prepared in each year in order to cope during emergency period. The site offices as Naubise, Gajuri, Mugling and Bharatpur are mainly responsible for emergency works. Number of machines and technical staff allocated in each

sites are as follows:

- Wheel loader -1
- tripper/Tractor-1
- Engineer-1
- Sub-Engineers-3
- Machine Operators-2
- Helpers and supporting staff-4

DOR is responsible to carry out on and off -road works within 25m from the Highway. However, DOR and DWIDP are carrying out their preventive and maintenance works in close collaboration. (Source: Road Division Office, Bharatpur, 2007)

(4) Road Maintenance Expenditure at the Project Office Level

Budget allocation for Narayangharh-Mugling Highway for Fiscal Year 2006/2007 are as follows:

Table 3.3.1 Road Maintenance Expenditure for N-M Highway for Fiscal Year 2006/2007

Routine Maintenance	NRs 606,513.00
Recurrent Maintenance	NRs 460,206.24
Recurrent Major	NRs 1027,564.80
Khahare Bridge Maintenance (Retaining/other structure/plumb concrete works)	NRs 360,877.00

Source: DoR

3.3.3 The Roles of Department of Road (DoR) in Environment Management

The major responsibility of the DOR is to build and maintain strategic roads and feeder roads. The Geo-Environment Unit (GEU), under the Planning Division is responsible for environmental issues of the Department and is not responsible for other roads that are constructed by DOLIDAR or DDCs. The GEU undertakes geo technical and bioengineering work as per the environment management plan developed after IEE or EIA. GEU is headed by a Senior Divisional Engineer heads with two additional engineers. Most government funded road projects does not have budget for environmental assessment and DOR initiates EIA is done only if the road construction entails trees removal from forests. Such studies are done by using external consultants. For donor funded projects, environmental assessments are carried out from Project funds and also through external consultants. For most big road projects, a separate project office is established and they lead the environmental assessment process. The role of GEU in such projects depends on the scope

highlighted in the project document.

In 1997, Environmental Management Guidelines have been prepared by DoR to ensure environmental considerations into the project survey and design, tender documents, contract documents, project supervision and monitoring.