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 I
Summary

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

PREFACE

In response to the request from the Government of Nepal, the Government of Japan decided to conduct "the Study on Disaster Management for Narayangharh-Mugling Highway," which was entrusted to Japan International Cooperation Agency (JICA).

Consequently, JICA sent to Nepal the designated Study Team, Nippon Koei Co., Ltd., headed by Mr. Masatoshi ETO, to execute related activities from July 2007 to February 2009.

The Study Team held discussions with concerned officials of the Government of Nepal, and conducted field surveys at the study area through close cooperation with said officials. Upon returning to Japan, the Study Team continued with further studies and prepared this final report.

It is hoped that this report will contribute to the promotion of effective risk management on Narayangharh-Mugling Highway and nationwide rode slopes, and to the enhancement of a friendly relationship between Japan and Nepal.

Finally, I wish to express my sincere appreciation to the concerned officials of the Government of Nepal for the close cooperation they extended to the Study Team.

February, 2009

Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

February, 2009

Mr. Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency (JICA)

LETTER OF TRANSMITTAL

Dear Sir,

It is our great pleasure to submit to you the final report of the “The Study on Disaster Risk Management for Narayangharh-Mugling Highway.”

The report contains results of the studies undertaken from July 2007 to February 2009 by the designated Study Team, Nippon Koei Co., Ltd., with the support of the local counterpart organizations namely, the Department of Water Induced Disaster Prevention (DWIDP) under the Ministry of Water Resources and the Department of Roads (DOR) under the Ministry of Physical Planning and Works.

We firstly thank the officials of your agency, including the members of your Nepal office and the experts dispatched to DWIDP, for their valuable advice and assistance rendered to the Study Team throughout the course of the study.

For accomplishing the study, besides valuable comments and suggestions from the members of the Steering Committee and Technical Working Group established by DWIDP and DOR, staffs from the central and regional offices of DWIDP and DOR extended their kind assistance and cooperation to the Study Team concerning many relevant places in Nepal. In conclusion, we also would like to express our sincere appreciation to all of them.

We deeply hope that the results of our study would significantly contribute to the development of a rational risk management system for the slopes along Narayangharh-Mugling Highway and other national highways in Nepal.

Very truly yours,

Masatoshi Eto
Team Leader
The Study on Disaster Risk Management for
Narayangharh-Mugling Highway

EXECUTIVE SUMMARY

1. Outline of the Study

Background

Among the national highway networks in Nepal, Narayangharh – Mugling Highway (N-M Highway) is one of the most important road sections, connecting Kathmandu with India. Due to heavy rains that occurred at the end of July 2003, many slides and debris flows were triggered heavily damaging section of this road as well as Ruwa Khola near Marsyangdi Power Plant, 4 km west of Mugling. The Government of Nepal (GON) immediately implemented rehabilitation of the road structures through the Department of Road (DOR) and directed the Department of Water Induced Disaster Prevention (DWIDP) to initiate preventive structural works. In addition to these, the GON decided to establish an effective and reasonable disaster risk management system for the important sections along N-M Highway.

In response to the request of the GON for technical cooperation, the Government of Japan decided to conduct a technical assistance through a study entitled **"The Study on Disaster Risk Management for Narayangharh – Mugling Highway"** (the Study).

Objective of the Study

Major objectives of the Study are as follows.

- To formulate basic strategy on disaster risk management considering result of risk assessment for N-M Highway
- To formulate structural measures for Ruwa River/Marsyangdi hydro Power Plant

Process of the Study

The Study commenced in July 2007 and was completed in November 2008. It was carried out to systematically accomplish the objectives through the following three phases.

- Phase I: July 2007 – November 2007: Risk assessment and planning basic strategy
- Phase II: December 2007 – June 2008: Feasibility study on basic strategy and preparation of pilot project
- Phase III: July 2008 – November 2008; Execution/ monitoring/ evaluation of pilot project

The Study has been successfully completed by the Team as scheduled, through close cooperation with the counterpart team composed of DWIDP and DOR designated representatives.

2. Overview of Slope Disasters on Study Area

The Study area is located in the southern-central of Nepal. Geological zones of the area are the Lesser Himalayan Zone and the Siwalik Zone. These zones are bounded by the Main Boundary Thrust (MBT) around chainage km 14, which is almost at the middle of the road section. The MBT and its related faults make the slopes prone to landslide and collapse.

Due to heavy rains that occurred at the end of July 2003, many slides and debris flows were triggered, heavily damaging sections along the road.

The daily rainfall amount from 1998 to 2006 obtained at at Devghat station was analyzed. Daily rainfall amount during the 2003 disaster is 446 mm with a return period of 16 years. This means that the rainfall frequency is 1/16 times per year. A high intensity rain of over 80 mm per hour is recorded during the disaster.

3. Hazard and Risk Assessment on Slope Disasters

Around 30 landside configurations were identified in the Study area based on interpretation of aero photograph/satellite image. It is realized that the sliding mass is not active at the moment. However, slopes which face the road and crossing streams over the road are prone to collapse according to the field geological survey.

The risks at 305 sites (134 mountainside slopes, 78 crossing streams, and 93 riverside slopes) on the N-M Highway were assessed with the aid of road slope disaster assessment sheets proposed in the Study.

Total potential annual loss (ALp) was estimated as 106 million Rs/year as of 2007. Among the three slope-types, the economical loss is attributed to mountainside slopes (66% of the total ALp) and crossing streams (32% of the total ALp). The risk of riverside slopes is very low (2% of the total ALp) since it had been provided with protection under the rehabilitation project by the DOR.

ALp of Ruwa River with existing structural measures (sabo dams constructed after the 2003 disaster) is estimated to be 4.9 million Rs/year as of 2007.

4. Basic Strategy on N-M Highway

ALp of N-M Highway in 2003 was 194 million Rs/year. This has improved to 106 million Rs/year as of 2007. The drastic improvement of the risk level from 2003 was due to rehabilitation works implemented by DOR from 2004 to 2006, and the preventive works carried out by DWIDP since 2004.

Basic strategy on the disaster risk management has been planned considering the result of the risk assessment. This involves a combination of structural and non-structural measures as follows.

Basic strategy I: Additional Structural Measures

Predominantly high risk eight sites (four crossing streams and four mountainside slopes), with estimated ALp of over 1 million Rs/year are selected. These shall be provided with structural measures costing approximately 204 million Rs.

Basic strategy II: Regular Maintenance and Quick Response

Regular maintenance and quick response for N-M Highway have been already formulated by DOR as part of the annual maintenance plans. These are consistently executed by the division road office (DRO) in Bharatpur. Quick response (reopening after road closure disaster) will be more efficient when linked with Road Early Information System (early standby of workers and equipment).

Basic Strategy III: Maintenance of Sabo Facilities

Six crossing streams with ALp of over 1 million Rs/year in ten years with sedimentation of sabo dams, were selected as priorities in the Study. The deposit removals for the prioritized six crossing streams havebeen proposed with an annual cost of 1.3 million Rs/year. Inventory of the damages of the sabo facilities has been already surveyed by DWIDP. Based on these data, maintenance plan for the sabo facilities will be formulated by DWIDP.

Basic Strategy IV: Road Early Information System / Basic Strategy V: Disaster Mitigation Activities in Communities (Kabilash Village)

Road Early Information System involves providing advice on road traffic obstacle information (road closure, traffic jam) and early warning (large rainfall amount, serious disturbance) for villagers and road users. This is implemented through notice boards, web page and FM radio broadcasting. Disaster mitigation activities in communities include 1) Hazard mapping, 2) Disaster education, 3) Early warning/ evacuation system, 4) Simple structural measures, and 4) Forestation and countermeasure planning.

Both systems are linked with local level disaster prevention partnership (good communication among stakeholders). Raingauges installed in the community contributed to the early warning system for both inhabitants and road users.

Evaluation for Basic Strategy

A benefit cost ratio (BCR) of 2.0 is determined for the additional structural measures for the eight sites. A BCR of 1.3 is calculated concerning the deposit removal for the prioritized six crossing streams. After structural measures to the eight sites and six crossing streams' deposit removal are completed, no other sites will be subjected to main high risks with ALp of over 1 million Rs/year.

Road regular maintenance, quick response (reopening) for road closure disaster, and road early information system are efficient methods in reducing the remaining risks.

5. Pilot project : Road Early Information System and Disaster Mitigation Activities in Communities

Basic strategies IV and V above involve systems that are new to GON. Therefore as part of the pilot project, test operation of the programs related to these systems were conducted by local counterparts and concerned organizations.

The pilot projects have been implemented by following concerned organizations.

- DRO, Bharatpur
- District Police Office (DPO)
- Kabilash VDC
- Mugling Narayangharh water induced disaster prevention project (MNWIDPP) office and/or Division No.3 office of DWIDP
- Kalika FM

The pilot project was managed by Planning and Review Committee (local level), which is composed of representatives from concerned organizations above, and headed by Chief District Officer (CDO).

Meanwhile, an Advisory Committee (central level) headed by DWIDP, composed of Ministry of Home Affairs (MOHA), DOR, and Department of Local Infrastructure Development and Agricultural Road (DoLIDAR) was formed.

The pilot projects have been successfully conducted. For the sustainable operation of the system, the following policies were then recommended and agreed during the Planning and Review Committee meeting held on November 2008:

- The committee for the systems shall convene twice a year, every May (before the rainy season) for the planning, and every November (after the rainy season) for the evaluation.
- The Planning and Review Committee shall be included in the early warning session of the Chitwan District Disaster Management Preparedness Committee. Offered
- Training drill shall be conducted every May (before the rainy season).

Warning criteria for heavy rainfall in road early information system and early warning/ evacuation system was initially set to “12 hour half-value rainfall amount in mm”, which will consist of accumulated hourly rainfall with subsequent rainfall reduced by half every 12 hours. This is deemed as an accurate method to acquire the characteristics of mixed hazard types (slope failure/ slide/ debris flow) on N-M Highway, as proven from analysis of past disasters’ records of arterial national highways in Japan.

DWIDP will coordinate the operation of the systems and analyze the data based on disaster management view points such as modifications to the warning criteria.

6. Structural Countermeasures for Ruwa River/ Marsyangdi Hydropower Plant

Countermeasures for protecting the power plant have been planned as below.

a) Removal of soils in the sabo dams; 8,500 m^3

b) Concrete walls to protect the power plant; right bank: 207 m, left bank: 57 m, total: 267 m

Construction cost is 18.4 million Rs and the BCR is 2.0.

7. Technical Transfer

A technical reference document entitled “Technical Guide on Sabo and Road Slope Protection Works” was prepared as a separate volume of the Study for more effective understanding of the work.

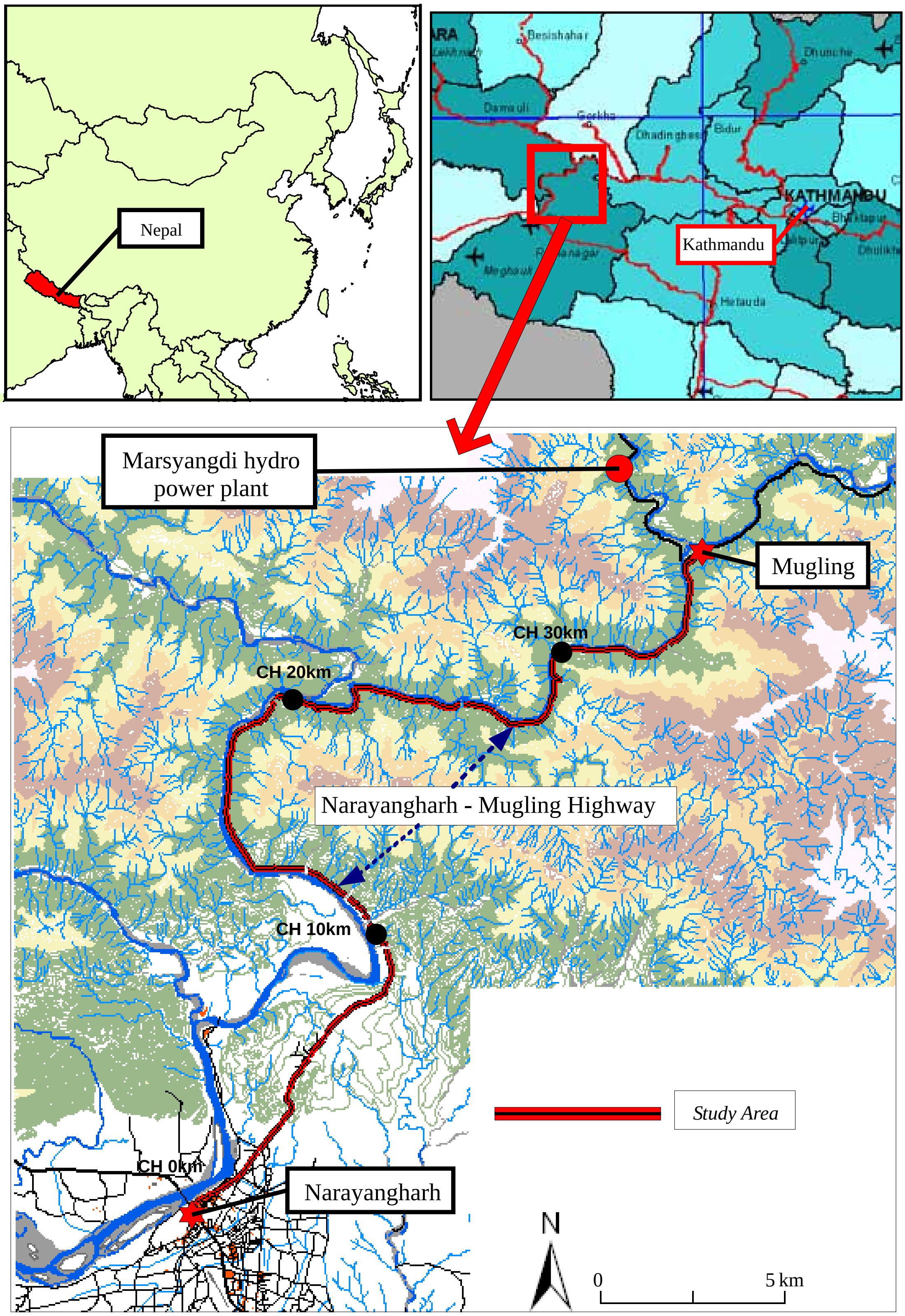
Technical transfer on the inhabitants’ road early information system and early warning/evacuation systems was conducted for the concerned organizations through training sessions, workshops and on-the-job trainings during the execution of the pilot projects.

The materials for education on disasters written in Nepalese were prepared for villagers and students of Kabilash Village. The education on disasters was carried out in September and October 2008. This education program will also be conducted in the future through the initiative of DWIDP.

8. Recommendation

The Study is focused on a limited area, but the basic strategies are applicable to other areas in Nepal that are subject to similar issues on water-induced disaster. Therefore, it is important not only to continuously implement the basic strategies in this specific community, but also to apply the system to areas prone to road slope disasters along sections of other national road networks.

Early warning/ evacuation system for villages prone to water-induced disasters should also be developed as part of the nationwide disaster management to further reduce casualties. Good partnership will result in efficient road disaster management and community disaster management.



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, Ministry of Environment, Science and Technology
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, Ministry of Physical Planning and Works
DOS	Department of Survey, Ministry of Land Reform and Management
DPTC	Disaster Prevention Training Center
DR	Discount Rate
DRO	District Road Office
DTM	Department of Transport Management, Ministry of Labor and Transport Management
DWIDP	Department of Water Induced Disaster Prevention, Ministry of Water Resources
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 I: SUMMARY

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List of Tables

The figures and the tables in the report which their references are not described were prepared by the JICA Study Team.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

In Nepal, a lot of disasters have occurred due to adverse natural conditions such as steep topography, fragile geology, heavy rainfalls during monsoon season, and earthquakes that occur intermittently. The roads in the mountainous areas are prone to frequent traffic blockade due to slope disasters. Narayangharh-Mugling Highway (hereafter referred to as “N-M Highway”), which is approximately 36 km, had been subjected to more than 20 serious failures such as slides and heavy debris flows that washout bridges. Severe damages have occurred along this road section due to heavy rains on 30th July 2003. This disaster affected the domestic industry and the logistics due to damaged roads which became impassable for a long duration. It also degraded the operation rates (40-50%) near Marsyangdi Power Plant at Ruwa Khola, 4 km west of Mugling. The N-M Highway is regarded as the most important road section connecting Kathmandu with India. Therefore, any traffic interruption paralyzes logistics, and cause catastrophic damage to the economy causing supply shortage and inflation in Nepal. It is noted that additional sabo facilities in Marsyangdi Power Plant are vital for the sustainable supply.

Well organized investigation and consequent preparation of basic plans is absolutely necessary for defining medium to long-term policy against slope disasters. The Government of Nepal (hereafter referred to as “GON”) had requested assistance from the Government of Japan for carrying out study on the technical issues.

In response to the request from the GON for the technical cooperation, the Government of Japan decided to conduct “The Study on Disaster Risk Management for Narayangharh-Mugling Highway” (hereafter referred to as “the Study”). Accordingly, the Japan International Cooperation Agency (hereinafter referred to as “JICA”), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, dispatched a preliminary study team to Nepal and agreed to the related Scope of Work (S/W) and Minutes of Meeting (M/M) held on 31st January, 2007. It was decided that the Study be conducted from July 2007 to February 2009, in accordance the S/W and the M/M.

1.2 Objectives of the Study

The objectives of the Study are as shown in Figure 1.2.1:

1) To formulate the basic strategy on disaster risk management for the N-M Highway and to confirm the validity of the corresponding disaster management project for the target area

2) To transfer the technology to the responsible and implementing counterpart organizations (hereinafter referred to as "the C/P") which are the Department of Water Induced Disaster Prevention, Ministry of Water Resources (hereafter referred to as "DWIDP") and the Department of Roads, Ministry of Physical Planning and Works (hereafter referred to as "DOR")

3) To formulate structural measures for Marsyangdi Hydro Power Plant in Ruwa River

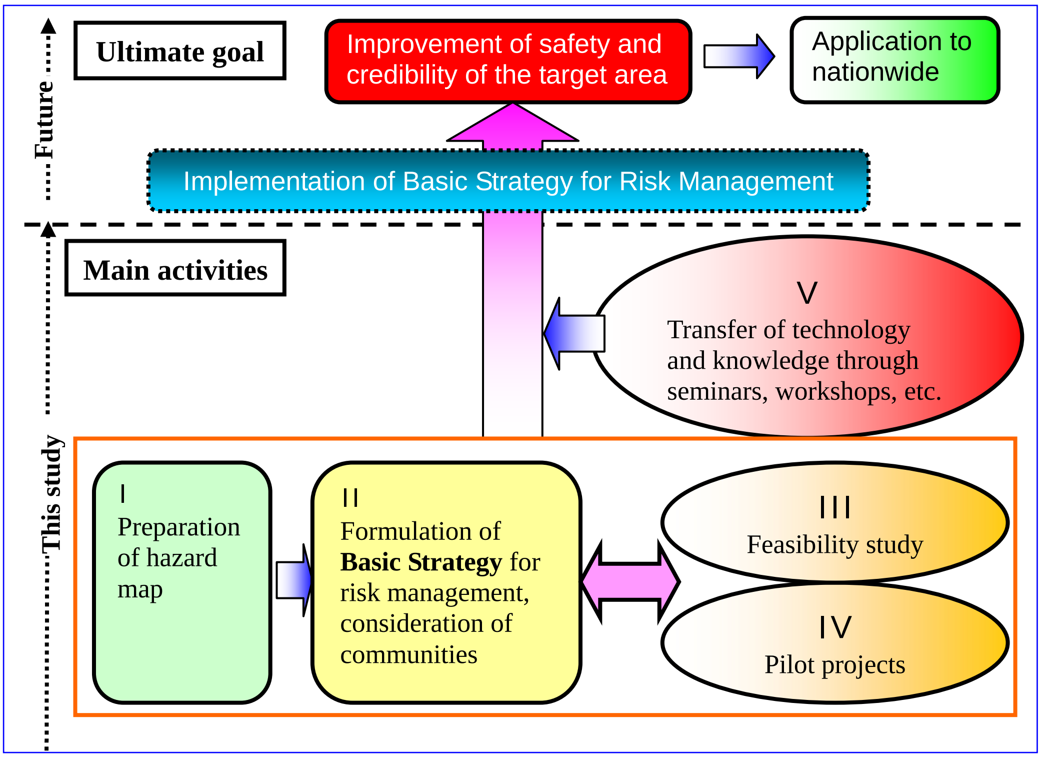


Figure 1.2.1 The Relationship between This Study and the Ultimate Goal

The results that will be obtained from this study can be applied to other important road sections/areas which are potentially affected by water-induced disasters such as the N-M Highway and neighboring areas and Ruwa River.

1.3 Study Area

The Study covers the following areas (Refer to the location map in the first page of this study):

(a) The N-M Highway and neighboring area (Road length: around 36 km, Residents in the vicinity: around 23,000)

(b) The Ruwa River basin beside the Marsyangdi Hydro Power Plant (Attachment area: around 2.69 km^2, Residents in the vicinity: around 2,500)

1.4 Implementation Framework

In accordance with the M/M on S/W of the Study dated 31st January 2007, the implementing organization established composed of JICA Headquarters and Nepal Office as the client, the DWIDP and the DOR as the Nepali C/Ps, and the JICA Study Team (hereafter referred to as "the Team"). Structure of implementation framework is shown in Figure 1.4.1.

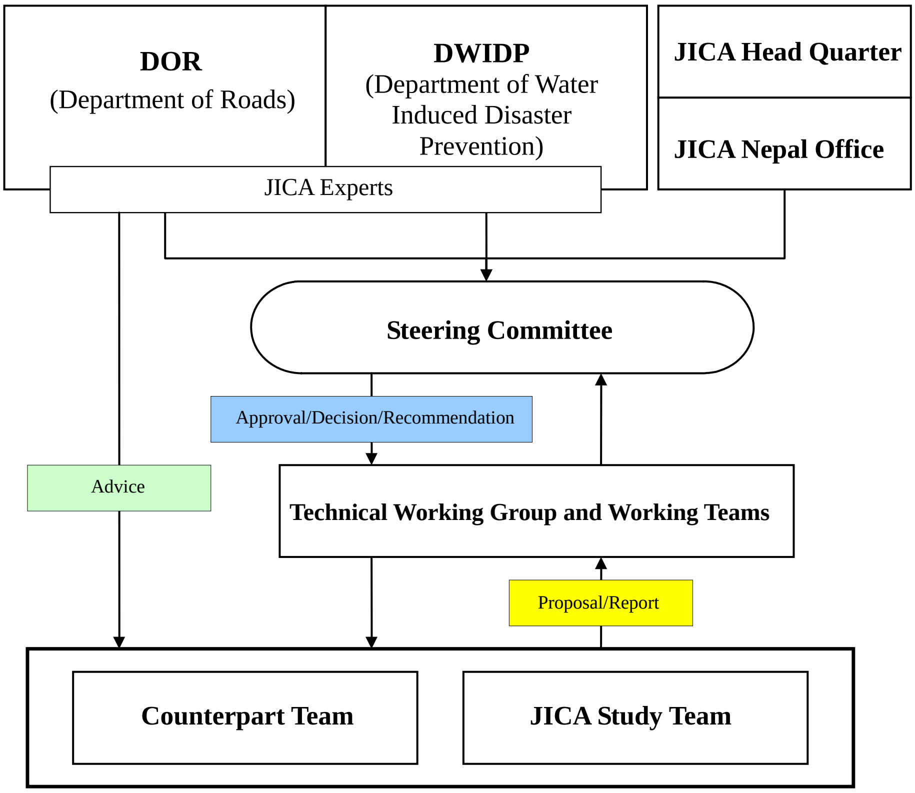


Figure 1.4.1 Implementation Framework of the Study

The Steering Committee (hereafter referred to as "the S/C") was set up to manage the implementation of the Study in accordance with the M/M. Additionally technical working groups (TW/G) or working teams for specific tasks are formulated to execute required tasks.

1.4.1 Steering Committee

The S/C has been set up to provide the Study with managerial instructions, evaluations reports, and other related information.

The 1st S/C meeting was held on 9th August 2007 to approve the plan of operation of the Study in accordance with the Inception Report. Meeting regarding the progress report was held on 4th November 2007 however, the chairperson was not available during said date. Hence, the official 2nd S/C was held on 27th November 2008 to discuss sustainable implementation of basic strategy.

The S/C was chaired by the Secretary of the Ministry of Water Resources. In addition to the committee members, the Nepali side invited the related donor agencies as observers, such as the World Bank and Asian Development Bank during the committee's meetings.

1.4.2 Counterpart Team

C/P Team assigned five engineers to conduct the study jointly with the Team.

1.4.3 Technical Working Group

On the initiative of the C/P, a (TW/G) composed of nine engineers was proposed to be set up, in view of the objectives of the Study. The TW/G aims to assist the S/C in organizing regular coordination meetings with the Team, and support the smooth implementation of the Study. The TW/G was be composed of designated representatives from DWIDP, DOR, and related organizations.

1.4.4 Study Team

The Team, composed of 12 engineers as shown in Table 1.4.1, implemented the Study in accordance with the plan of operation outlined in the IC/R. .

Table 1.4.1 List of JICA Study Team Members

Position/Specialties	
Masatoshi ETO	Team leader/ control of soil erosion and rivers
Takashi SUGIMOTO	Co-team leader/ control of soil erosion and rivers
Mikihiro MORI	Road (disaster) management
Kenichi TANAKA	Geology
Hiroyuki ONO	Social/economy
Takeshi KUWANO	Environmental/social consideration
Khadananda LAMSAL	Hydrology
Puchai YANG	Cost estimation
Satoru NODA	Project coordinator
Yusuke NUMATA	Disaster information management
Tamaki MATSUO	Disaster management, environmental/social consideration
Junichi KITAGAWA	Structural countermeasure works

1.5 Schedule and Items of the Study

The Study has been implemented for around 20 months, form 5th July 2007 to 27th February 2009. Progress schedule and specific work items related to the Study are shown in Table 1.5.1.

Table 1.5.1 Schedule and Work Items of the Study

Schedule	2007						2008												2009	
	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2
Year	First Year									Second Year										
Phase	Phase I					Phase II							Phase III							
Activities																				
Items		1st Field Work					2nd Field Work				3rd Field Work						4th Field Work			
Report: Inception Report (IC/R)																				
Report: Progress Report (P/R)																				
Report: interim report (IT/R)																				
Report: Draft Final Report (DF/R)																				
Report: Evaluation Report (E/R)																				
Report: Final Report (F/R)																				
Phase I																				
1st Work in Japan																				
【1】 Data collection and analysis in Japan																				
【2】 Review of policies; preparation of the work plan and methodology																				
【3】 Preparation of the Inception Report (IC/R)																				
1st Field Work																				
【4】 Meeting on the Inception Report																				
【5】 Data collection																				
【6】 Field reconnaissance																				
【7】 Geological survey																				
【8】 Review of existing plans and studies, organizations, and legal systems																				
【9】 Analysis of relationship between rainfall and disasters																				
【10】 Definition of words on slope disasters																				
【11】 Analysis of data and information																				
【12】 Technical advice on structural measures																				
【13】 Disaster risk assessment in the study area																				
【14】 Formulation of a comprehensive hazard map																				
【15】 Concept formulation of the disaster risk management																				
【16】 Formulation of Basic Strategy																				
【17】 Preparation for pilot projects and monitoring of slides																				
【18】 Preparation/explanation/discussion of the Progress Report (P/R)																				
Phase II																				
2nd Field Work																				
【19】 Selection of the sites																				
【20】 Implementation of feasibility study (F/S)																				
【21】 Preparation/explanation/discussion of the interim report (IT/R)																				
3rd Field Work																				
【22】 Pilot project and monitoring of slides																				
【23】 Technical advice on structural measures																				
【24】 Preparation/explanation/discussion of the Draft Final Report (DF/R)																				
Phase III																				
4th Field Work																				
【25】 Evaluation for pilot project and monitoring of slides																				
【26】 Technical advice on structural measures																				
【27】 Preparation/explanation/discussion of Evaluation Report (E/R)																				
2nd Work in Japan																				
【28】 Preparation/submission of the Final Report (F/R)																				

Field work   1st Work in Japan   2nd Work in Japan

CHAPTER 2

OVERVIEW OF SLOPE DISASTERS ON NARAYANGHARH – MUGLING HIGHWAY

2.1 Natural Conditions Related to Slope Disaster in the Study Area

2.1.1 Topography and Geology

(1) Topography with Chainage

Narayangharh-Mugling Highway (hereafter referred to as "N-M Highway") is at the left side slope of the valley surrounded by the Trishuli River and at an elevation of approximately 250 m. Relative heights from the highway to the ridges vary with a minimum of about 750 m.

Topographically, the section of CH[1] (Chainage: distance in km from Narayangharh) 10 km to 36 km can be roughly divided into two sections, CH 10 km to 14 km and CH 14 km to 36 km. Section CH 10 km to 14 km is located in the Siwalik Zone mentioned above. Along this section, the Trishuli River runs toward east to south east. Natural slopes along the road face from south to southwest. Within this section, there are three major branches of the Trishuli River, i.e. Das Khola at CH 12+600 m, Khahare Khola at CH 11+300 m, and Jugedhi Khola at CH 10+300 m.

Meanwhile, section CH 14 km to 36 km is located in the Lesser Himalayan Zone. Along this section, the axis of the Trishuli River winds north to south or east to west, and flows to the Siwalik Zone. Based on the Trishuli River meandering, natural disaster/cut slopes along the road generally face north or west. At CH 25+500, the Trishuli River meets the Rigdi Khola, the largest watershed in the Study Area.

(2) Geology with Chainage

Bedrock found in the Study area comprises of rocks of the Lesser Himalayan Zone and the Siwalik Zone as mentioned above. The Lesser Himalayan Zone and the Siwalik Zone are bounded by the MBT. Within the study area, the MBT seems to cross at about CH 14+500 of the highway. Table 2.1.1 shows strata and rocks of each zone.

[1] Refer to the location map in the opening page or Figure 2.3.1

Table 2.1.1 Strata and Rocks in Study Area

Group / Formation		Lithology	Engineering property
dn	Dun Formation	Molassic sediments	Loose, unconsolidated
si	Siwalik Group (Neogene)	Molassic sandstone, mudstones, conglomerates	Soft-medium hard rocks
Nawakot Complex			
Upper Nawakot Group (Upper Paleozoic)			
bg	Benighat Slates	Dark blue-gray argillaceous slates and phylliets, black carbonaceous slates	Medium-hard rock Well-foliated
Lower Nawakot Group (Upper Precambrian – Lower Paleozoic)			
dh	Dhading Dolomite	Light blue-grey dolomite, dense stromatolitic; alga, echinoderms (Lower Paleozoic)	Hard rock, massive, often forming steep cliffs and the Karst
np	Nourpul Formation	Phyllites and alternation of phyllite / quartzite and phyllite / dolomite; colour-banding.	Medium – hard rock
pb	Purebesi Quartzite Memebr	Strongly ripplemarked orthoquartzite	Hard rock, sometime massive, forming steep cliffs
da	Dandagaon Phyllites	Dark green grey phyllites, some calc phyllites, rare thin limestones and quartzite	Medium – hard rock, well foliated
fg	Fagfog Quartzite	White orhtoquartzite, ripplemarked, with phyllite interzones.	Hard rock, forming steep cliffs, often massive
kn	Kuncha Formation	Phyllites, phyllitic quartzites, greywackes, conglomerates, rare basic (amphibolitic) layers.	Medium – hard rock

"Group/ Formation" by Photo-geological Map of Part of Central Nepal (1982)

Along the southern section of CH 10 to 14, road slope geology comprises of sedimentary rocks of the Siwalik Group, and the quaternary terrace/talus deposits. Rocks of the Siwalik Group are distributed in the NE-SW direction, dipping towards northwest, and showing monocline structure.

2.1.2 Climate

Elevation of the adjoining areas along the highway ranges from 200-900 m from the MSL, therefore, sub-tropical climate prevails within the vicinity of the highway. In winter, temperature ranges from 6-25^{o}C in the surrounding areas of the highway. Meanwhile, in summer, temperature at the southernmost and depressed part of the highway (i.e Narayangharh and surrounding areas) rises considerably high while at the areas lying on elevated places on the northernmost part of the highway are with fair climate. Moreover in summer, temperature ranges from 25-40 ^{o}C in the surrounding areas of the highway. Green forests prevail throughout the highway. For reference purposes, the monthly maximum temperature and daily rainfall recorded at Bharatpur station during 2002-06 were analyzed. A highest maximum temperature of 41.2^{o}C was recorded in May, 2004. It was found that April, May and June are the hottest months with average maximum temperature of 37.8 ^{o}C, 39.3 ^{o}C and 38.6 ^{o}C, respectively. The mean annual rainfall in the area is about 2650 mm.

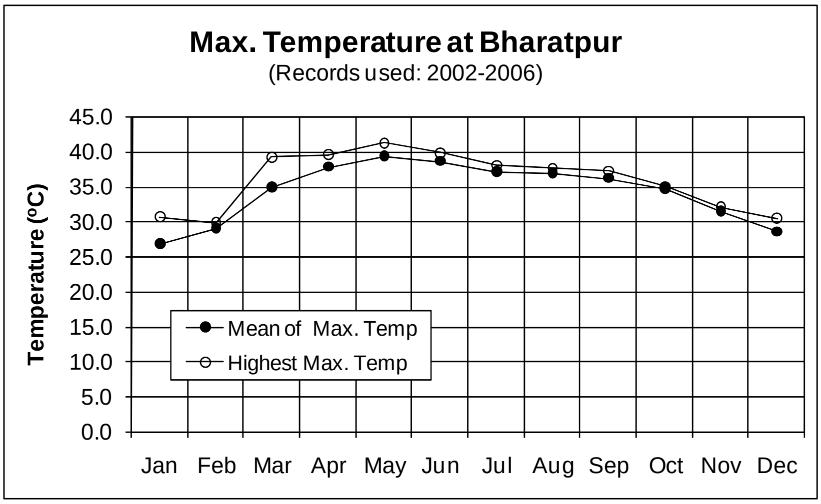


Figure 2.1.1 Maximum Air Temperature of Bharatpur Station

2.2 Social Condition of the Study Area

2.2.1 Outline of the Study Area

(1) Location of the Study Area

The Study area is composed of the Kabilash, Darechok, Dahakhani and Chandi Bhanjyang VDCs and Bharatpur Municipality in Chitwan district. Most areas along the Nayarangharh-Mugling Highway which are prone to disaster, include Kabilash VDC that stretches between the sections CH 10 km to 26 km of the highway. Thus studies on social conditions are mainly concentrated in the Kabilash VDC. Its location is highlighted in the map.

(2) Population

According to the Central Bureau of Statistics (CBS) of 2003, the total number of households in the Kabilash, Darechok, Dahakhani and Chandi Bhanjyang VDCs were 985, 1648, 589 and 813, respectively.

(3) Economic Condition

Rain-fed agriculture is being practiced in the Study area due to lack of irrigation facilities. Similarly, method of raising livestock is conventional using available local breeds which seem less productive. Therefore, income generated from the agricultural production and raising livestock is not enough to maintain the livelihood. Hence, it is common for the youths in the area to leave their village and seek opportunities either to other domestic cities or overseas, working as unskilled labors in order to support the families.

Due to steep geographical condition, the cultivated area is very limited. Therefore, income from agricultural sources is insignificant and is difficult to sustain for a period of six months.

(4) Agriculture Condition

Total cultivated land of the Study areas is estimated as 1326 hectare with only 108.8 hectares (8.2 percent) under irrigation.

(5) Drinking Water Situation

About 83.0 percent of the households obtain drinking water from pipes linked to water sources. The remaning 17 .0 percent obtain water directly from other sources such as wells, river etc.

(6) Education

In the study area, only 46.6 % of the population can read and write. Moreover, male has higher literacy rate of 59 % while female with 41 %.

Education and service institutions are important for uplifting the socio-economic conditions. These are also essential in rendering institutional services during planning and implementation of development programs in above study areas.

(7) Environmental Condition

Environmental condition in adjoining villages along the N-M Highway has degraded. Natural disasters like landslides, floods and debris flows occur frequently during rainy seasons. Fragile geology is the main reason that affect environmental situation in the Study area. The social and economic conditions of the people in the areas are also affecting the environmental degradation and induce water disasters. Poverty is realized as the primary cause while lack of awareness and education are secondary factors in affecting the current environmental condition. Similarly, deforestation and excessive grazing are the main reasons that cause slope disasters.

2.2.2 Social Condition of Kabilash Village

(1) Administrative Structure of Village

Kabilash Village is governed by the village development committee (VDC) represented by a Chairman, a Vice- Chairman, and nine Ward Chair Persons (one from each ward) and 36 Ward Members (four from each ward). The VDC is entrusted with powers, functions and responsibilities within the village development area.

The development projects completed by Kabilash VDC in 2006/2007 include construction of primary school buildings, procurement of electric posts, provision of trail roads, drinking water and small scale irrigation system. These projects were implemented under the financial assistance of District Development Committee of Chitwan. The total estimated budget of VDC in 2007/2008 is NRs 2,265,000.

(2) Land Use

The land-use pattern in Kabilash is presented in the following figure. Most of the land areas are covered with forests.

(3) Disaster Prone Areas in Kabilash Village

Disasters prone areas in Kabilash are in wards 1, 6, 8 and 9 (Figure 2.2.1). In 2003 and 2006, disasters occurred in these wards, with many lives and properties lost due to landslides and debris flows. Therefore, much attention should be paid on these areas concerning disasters risk management.

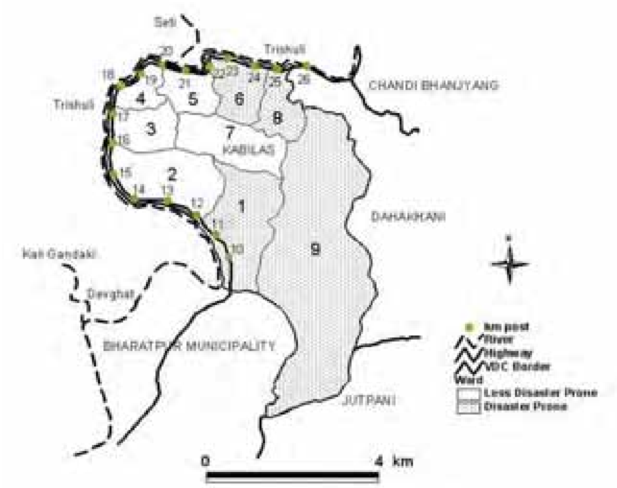


Figure 2.2.1 Disasters Risk Areas of Kabilash Village

2.2.3 Disaster Management in National Level

(1) Institutional Arrangements for Natural Disaster Relief

In general, Nepal is highly prone to various types of disasters with major ones induced by water. Each year after occurrence of disasters, approximately a thousand people are killed, about one hundred were lost and thousands of families are demoralized. In addition, properties worth millions are ruined. To cope with such natural calamity, a disaster management system has been formulated in the national level.

(2) National Action Plan on Disaster Management

The major programs and activities on disaster preparedness, response, reconstruction, and mitigation action plan have been formulated in 2001 as follows.

(3) Activity of DWIDP

Water Induced Disaster Prevention Technical Centre (DPTC) was established in 1991.

Eventually, it became the DWIDP in February 2000 under the Ministry of Water Resources as the lead agency. The three major activities in DWIDP that contribute to mitigation and reduction of water induced disaster in Nepal. (Source: DWIDP, an Introduction)

(a) Technology Development Work
(b) Training, Study and Introduction Work
(c) Water Induced Disaster Mitigation Work

(4) Activities for Road Maintenance Work of Division Road Office (DRO), Baharatpur, Chitwan

DRO, Bharatpur is responsible for disaster management and maintenance of strategic roads in Chitwan and Dhading districts of Nepal. These roads comprise 186 km national highways and 23 km feeder roads. In addition to this, the office is also involved in construction of major bridges in said two districts.

2.2.4 Rainfall Feature in the Study Area

The accumulated rainfall amounts and intensities have been adopted as threshold in Japan. However, it is has been indicated that they do not have enough accuracy for prediction. In this study, the modified rainfall amounts of 6, 12 and 24-hour half-values, which were estimated using the annual maximum daily rainfalls of 1998-2006 from Devghat station, were considered instead of the accumulated rainfall amount for early warning. Its purpose is to increase reliability of early warning against rainfall triggered disasters.

The maximum modified rainfall amounts estimated were computed for based on maximum annual daily rainfall days during 1998-2006 at Devghat station. The return periods 6, 12 and 24-hour half-value and 24-hour recorded maximum 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. In 2006, based on similar return periods, 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 half-value modified rainfall amounts (Table 2.2.1). Consequently, this 12-hour half-value modified rainfall with in-between value return period, can be used effectively for early warning of disasters which occur due to high intensity rainfall as well as for mild and long duration rainfalls. Therefore, this half-value modified rainfall amount is finally used as threshold value for early warning to control traffic and facilitate residents' evacuation from the N-M Highway.

Table 2.2.1 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

The early warning system should be developed for minimizing loss of properties and lives from disasters triggered by rainfall that occur on the highways and villages. Hence, two separate early warning criteria are proposed for traffic control on the highway and for evacuation of village residents, as shown in Table 2.2.2.

Table 2.2.2 Warning Levels by the Modified Rainfall Amounts

<table>
<tr><th rowspan="2">Warning Level</th><th rowspan="2">Threshold rainfall amount</th><th colspan="2">Action</th></tr>
<tr><th>for the Highway</th><th>for Residents Evacuation</th></tr>
<tr><td>Level IV</td><td>24-hour half-value modified rainfall amount : 180mm
Return periods: 10-year</td><td><u>Warning:</u>
Recommendation mentioning road is unsafe</td><td rowspan="2"><u>Warning:</u>
Recommendation for evacuation</td></tr>
<tr><td>Level III</td><td>24-hour half-value modified rainfall amount : 140mm
Return periods: 5-year</td><td><u>Caution:</u>
Recommendation mentioning careful road passage</td></tr>
<tr><td>Level II</td><td>24-hour half-value modified rainfall amount : 80mm
Return periods: 2-year</td><td rowspan="2"><u>Preparation:</u>
(DRO)Calling up staff/ workers/equipment for emergency action
Upload to web-page of DRO and Kabilash VDC the amount of 1 hour rainfall</td><td><u>Caution:</u>
Recommendation to prepare for evacuation</td></tr>
<tr><td>Level I</td><td>24-hour half-value modified rainfall amount : 60mm
Return periods: 1-year</td><td><u>Preparation:</u>
Informing the committee, monitoring team, Ward representative in VDC.
Upload to web-page of DRO and Kabilash VDC the amount 1 hour rainfall</td></tr>
</table>

2.3 Road Slope Disasters on Narayangharh-Mugling Highway in 2003

2.3.1 The characteristics in 2003 disaster

The boundary of the debris movement characteristics in the slope is Station 15 as shown in Figure 2.3.1 below. Characteristics of the road slope disaster in each area are also shown in said figure.

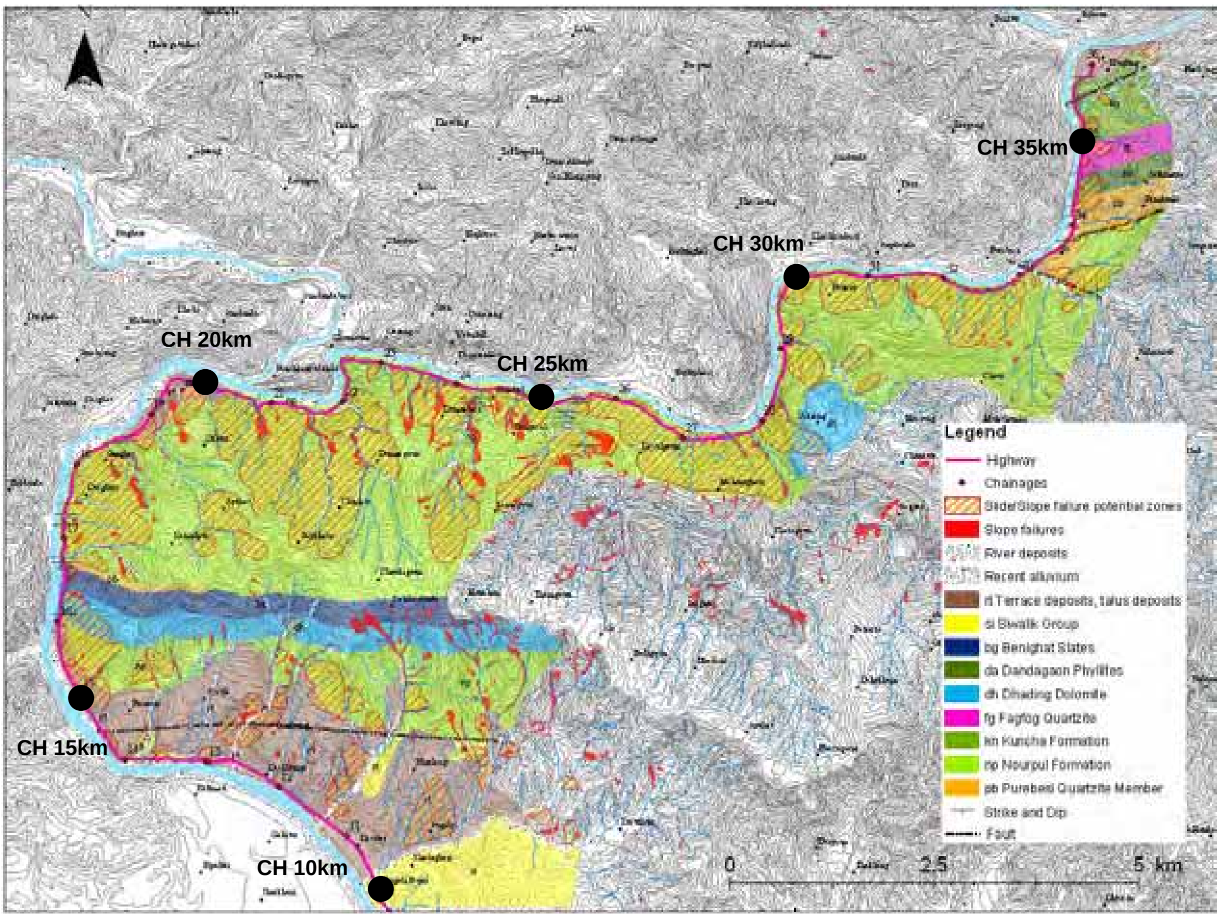


Figure 2.3.1 Hazard map for CH 10 to 36 of N-M Highway

2.3.2 Damages in 2003 disaster

(1) Damages Caused in the Villages along the Highway

The damages caused by 2003 and 2006 disasters in the villages lying along the highway were studied. In the 2003 disaster, 18 people died and 69 houses were destroyed in Kabilash.

Table 2.3.1 Lives and Properties Lost in Villages during 2003 & 2006 Disasters

Year	VDC/District	People		Affected Family (Nos)	Livestock Loss (Nos)	House Destroyed (Nos)	Public Properties Losses	Estimated Loss (NRs)
		Death (Nos)	Injured (Nos)					
2003	Darechok	1		2	13	2		440,000.00
	Chandi Bhanjyang	9	5	4	44	5	Culvert, School-1	530,000.00
	Kabilas	18		69	164	69	Road	2,022,000.00
2006	Kabilas	3				15		NA

Source: Disaster Review 2003 & 2006, DWIDP & VDC Records

(2) Damages Caused on the Narayangharh-Mugling Highway

Damages recorded caused on the N-M Highway are presented in Table 2.3.2.

Table 2.3.2 Properties Lost on N-M Highway by 2003 Disaster

S. N.	Property	Destroyed Units
1	Bridges Destroyed (Nos)	2
2	Culverts Destroyed (Nos)	9
3	Road Pavement Destroyed (m)	8675
4	Retaining Wall Damaged (m)	494
5	Embankment Damaged (m)	1480

Source: DWIDP Bulletin 2005-6

(3) N-M Highway Rehabilitation Works by CDRO after 2003 Disaster

Besides debris clearance works to allow for vehicular movement on the N-M Highway after the 2003 disaster, CDRO has also constructed slope stabilization structures along the highway as preventive measures against slope disasters.

Table 2.3.3 CDRO's Rehabilitation Works after 2003 Disaster

S. N.	Structure	Constructed Unit
1	Breast walls (m)	809
2	Retaining walls (m)	538
3	Check dams (Nos)	42
4	Guide walls (m)	104
5	Anchor walls (Nos)	4
6	Catch pits (Nos)	7
7	Toe walls (m)	269
8	Spur (Nos)	1

Source: DWIDP Bulletin 2005-6

2.4 Debris Flow Disaster at Ruwa Khola in 2003

The 2003 rainfall and its triggering debris flow in the Ruwa Khola on July 30 caused severe damage to the power plant, stopping its operation for nine days with a direct loss of about 1.0 billion Rs.

2.4.1 Outline of Debris Flow Disaster

(1) Occurrence Time and Triggers

Date and time of Occurrence: AM 2:00, July 30, 2003

Trigger: Continuous rainfall from 17:00, July 29 (446.2 mm from 8:45 a,m., July 30 to 5:00 a.m., July 31, at Devghat Station)

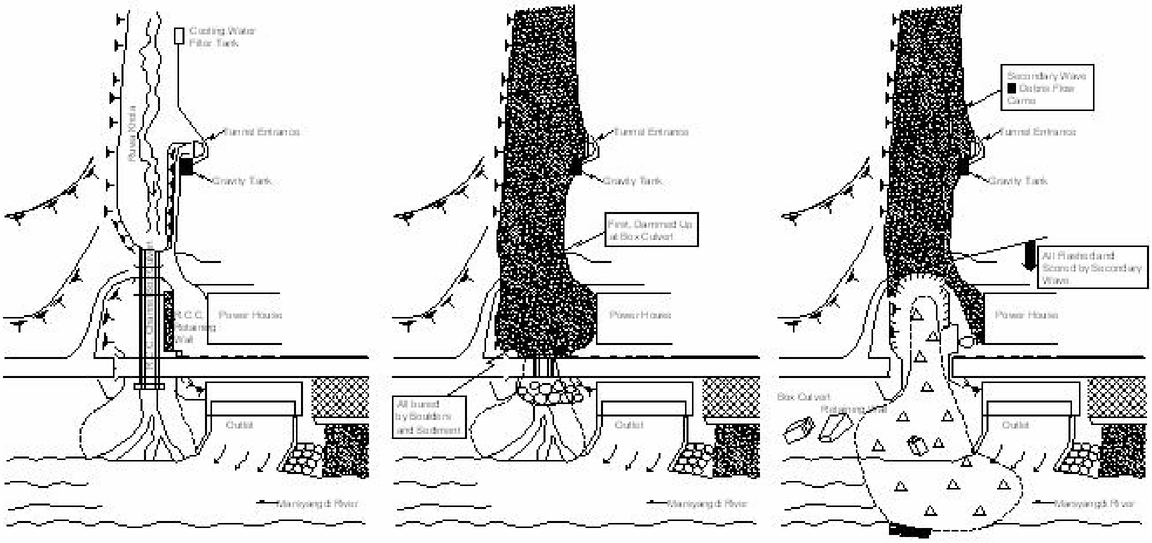
(2) Debris Flow Disaster

Based on field reconnaissance, occurrence of debris flow disaster is summarized, as follows:

a) Slope failures on the valley slopes upstream of the power plant and associated debris flows that produced a large amount of debris materials.

b) There used to be a foot trail crossing the river just upstream of the mouth of the Ruwa Khola before the debris flow disaster occurred. With the rising of the riverbed, the debris flow sediment gradually spread out laterally and partially to the inlet of cooling water tunnel and the power plant.

c) When the second debris flow occurred, the natural dam was eroded and consequently failed, causing a larger volume of debris flow. The failed sediments flowed along the debris materials discharged into the Marsyangdi River. It obstructed the river flow and cause rising of river water.



a) Before debris flow

b) When the first wave of debris flow occurrence

c) After the second wave of debris flow occurrence

Figure 2.4.1 Conceptual Illustration of the 2003 Debris Flow Occurrence

2.4.2 Associated Damages

(1) Power plant

a) The power plant building was buried under debris flow sediments.

b) The building foundation was exposed due to debris flow. Emergency measures using gabion walls were executed.

c) Debris flow from the Ruwa Khola blocked the Marsyangdi River. The river water and associated debris materials flowed into the tailrace tunnel which faces the Marsyangdi River.

(2) Other facilities

a) Outlet of cooling water tunnel facing the Ruwa Khola was buried under debris flow deposits.

b) Water supply pipe was washed out by debris flow.

c) Te box culvert just upstream of the confluence of the Marsyangdi River and the Ruwa Khaola was completely washed out by the associated debris flow

d) The bridge foundation was partially washed out by the associated debris flow.

CHAPTER 3

HAZARD AND RISK ASSESSMENT ON SLOPE DISASTERS

3.1 Slope Disaster Types along Narayangharh – Mugling Highway

Hazard and risk assessment was conducted considering the following:

A. Qualitative assessment of the stability of slopes

B. Risk assessment for selected slopes along the road applying the evaluation method proposed by the Team.

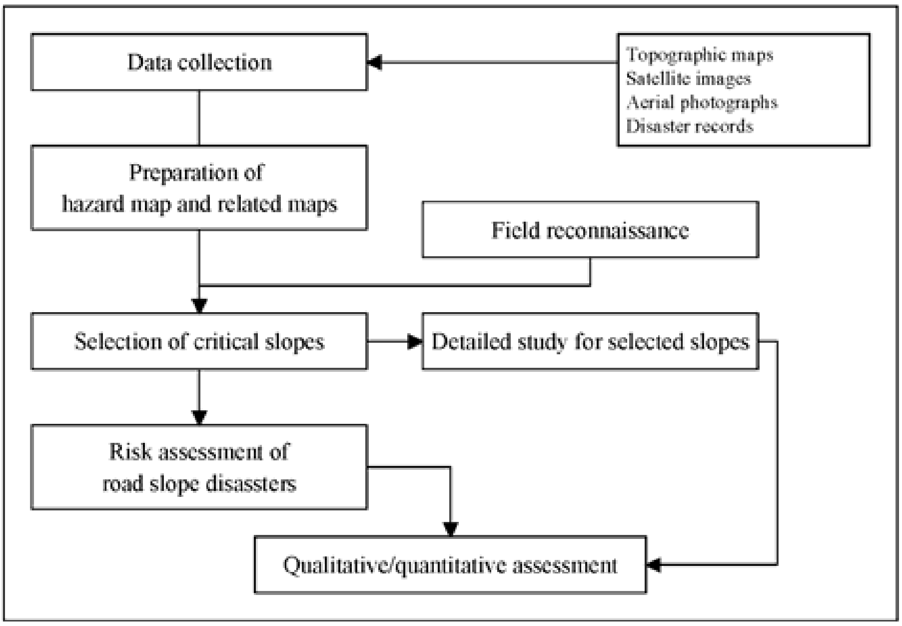


Figure 3.1.1 Flow of Slope Hazard/Risk Assessment

3.2 Stability Assessment of Selected Landslide Sites

3.2.1 Selected Sites

The Team selected four sites (hereinafter described as SL) that are considered as large-scale landslides adjacent to the highway. The sites were initially identified based on preliminary field reconnaissance jointly carried out by the DWIDP and the Team on August 2 and August 3, 2007. After selection of the sites, the Team planned the survey items and quantities of the work to be executed by a Nepalese local consultant firm.

3.2.2 Site Conditions

The selected four sites are north-facing and dip-slip slopes as mentioned in Section 3.2.1. Bedrock of the sites comprises meta-sedimentary rocks of the Nourpul Formation.

Table 3.2.1 below summarizes the existing site conditions of the selected sites.

Table 3.2.1 Condition of Selected Sites

Site	Conditions
SL-1	SL-1 is a north-facing and dip-slip slope. Many deformations related to landslide could be identified, e.g., open cracks of the road-side retaining walls, spring water, rotation of gabion walls, and rock falls. The site shows a typical topographic shape of a landslide. Bedrocks comprise meta-sedimentary rocks of the Nourpul Formation and unclassified intrusive basic rock that forms a steep cliff around an elevation of 380 m.
SL-2	SL-2 is a north-facing and dip-slip slope, located approximately at CH 23+600 m. Currently an unstable rock mass have been sliding toward the highway. Masonry road-side retaining wall below the unstable rock mass had been deformed due to rock mass sliding. The cracks on the masonry wall were visible in early of August 2007. The cracks had been widened gradually during the monsoon in 2007, and finally it was collapsed due to heavy rainfall on September 17 in 2007. Bedrocks of the site are of the Nourpul Formation. Slope surrounding this unstable rock mass is at risk of sliding. The unstable rock mass had remained on the slope above the road.
SL-3	SL-3 is a north-facing and dip-slip slope located at CH 24 approximately. At the riverside slope of the site, a concrete wall with anchoring was constructed as countermeasure. Furthermore, concrete blocks have been placed on the riverbed to protect riverside slope from river water erosion. Similar to SL-2, there is an unstable rock mass sliding towards the highway. The road-side retaining masonry wall had been deformed and cracked. Finally. it failed on September 4, 2007, due to the heavy rain fall on September 3, 2007. The unstable rock mass had remained on the slope above the road. Slope including the unstable rock mass has many deformation suggesting landslide, e.g., open cracks, scarps of slope failures, spring water from cracks of the bedrocks, kink bands and micro-folds of foliations, disturbance of foliations and bedding planes. Around an elevation of 350 m, contour lines show a convex shape suggesting a scarp of a landslide.
SL-4	SL-4 is a north-facing and dip-slip slope, similar to other selected sites, and located at CH 24+500 approximately. There were few positive indicators suggesting active landslides. However the slope seemed to show a typical shape of a large-scale landslide based on the topographic map or a high-resolution satellite image. Geometrically this site is projecting towarda the Trishuli River, and it was considered to be formed by landslide movement. Bedrocks of SL-4 are phyllites with sandstones of the Nourpul Formation, often intercalates quartzite beds. There is a retaining-concrete wall along the river-side slope of the road, and concrete blocks have been placed on the riverbed to protect the foot of the slope from river water erosion similar to SL-3.

As shown in Table 3.2.1, bedrocks of the selected four sites generally consist of alternating beds of phyllite and sandstone of the Nourpur Formation. Moreover, all sites are facing north and of dip-slip slope. Results of geological studies are summarized below.

3.2.3 Study Results

(1) SL-1

Potential Hazard

The landslide (Block 1A) is related to a dip-slip structure. Loose material of lower slope has been pushed by material of upper slope towards the road.

Landslide at SL-1 was originally caused by a bank erosion at the Trishuli River. Consequently, the landslide and related slope failures are considered to have been activated by the cutting of the landslide potential slope (Block 1A) during the construction of the highway.

Once Block 1A starts sliding down to the highway, sliding of block (Block 1B) is expected to occur.

For preventing hazard, groundwater should be drained appropriately with suitable countermeasure, e.g., provision of additional horizontal drain holes.

Among the selected sites, SL-1 has the highest hazard potential, and is a typical landslide site.

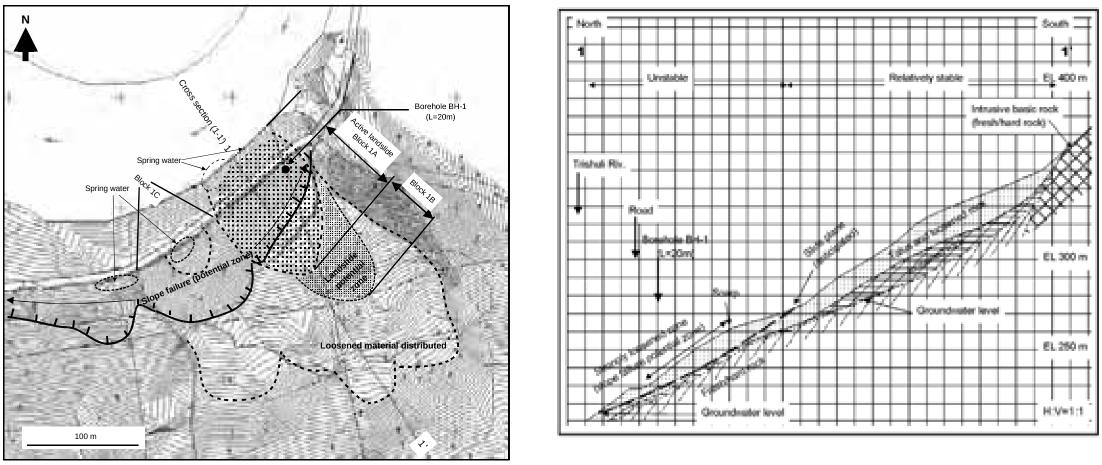


Figure 3.2.1 Plan View and Cross Section of SL-1

(2) SL-2

Potential Hazard

It is considered that the movement of the Block 2A was initiated during the slope-cutting prior to opening of the highway. The unstable rock mass movement is related to geological structure, i.e., dip-slip structure. An assumed sliding plane is a bedding plane of the bedrock (probably made up of sandstone). Once Block 2A collapses, Block 2B will move towards the road.

However, the size of Block 2A is only about 600 m^2, which is considered relatively small for a landslide. Such occurrence is common along the highway, but not considered serious. For the mountain-side slope, loose rocks (shown in Figure 3.2.2) beneath the ground surface should be retained with suitable countermeasures. On the other hand, the river-side slope below the road seems to be currently stable. The target for countermeasures is the road-side slope as shown in Figure 3.2.2.

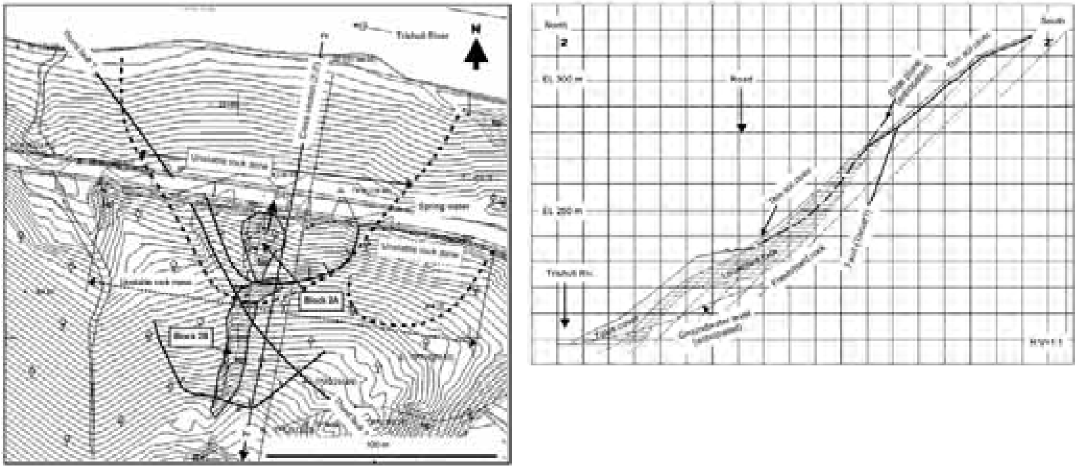


Figure 3.2.2 Plan View and Cross Section of SL-2

(3) SL-3

Potential Hazard

Landslide movement of Block 3A and Block 3A1 seemed not active. However during rainy season, it could be activated if heavy rain occurs.

Firstly, the landslides Block 3A and Block 3A1 had been initiated due to bank erosion at the Trishuli River. Subsequently, slope cut during the opening of the road had accelerated the landslide-related movement.

On the other hand, rock-sliding along bedding planes or slope failures within shallower depths (up to 5 m depth) of the cut slope are more active than the big landslides (Block 3A including Block 3A1). Such current slope behavior is considered as a landslide-related movement. Furthermore, slope failures on the cut slope below E.L. 260 m seem to extend to both sides of the Block 3A1 along the road.

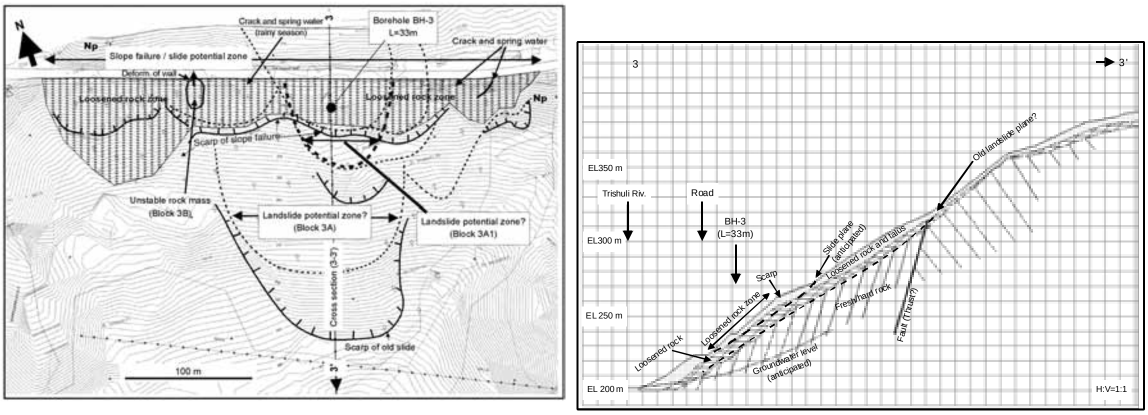


Figure 3.2.3 Plan View and Cross Section of SL-3

(4) SL-4

Potential Hazard

Risk of a big landslide moving towards the highway is low. Potential hazards to the highway are slope failures and rock falls from Block 4A and its adjacent slopes. These slope failures seem to be initiated by the cutting of the slope during the opening of the road.

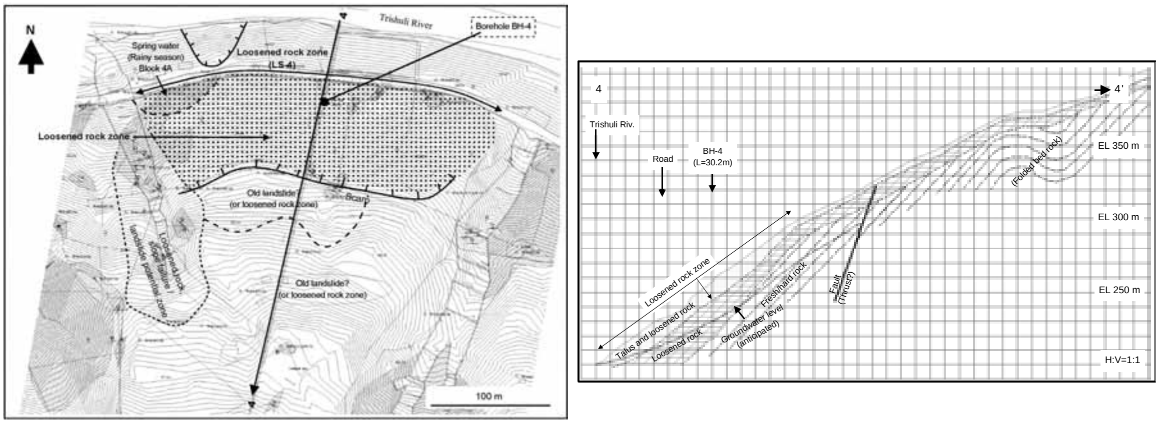


Figure 3.2.4 Plan View and Cross Section of SL-4

3.2.4 Potential of Big Landslides along Highway

Table 3.2.2 summarizes the landslide potential assessment results for SL-1, SL-2, SL-3, and SL-4.

Table 3.2.2 Evaluation of Landslide Hazard Potential for SL-1, SL-2, SL-3 and SL-4

Site		SL-1	SL-2	SL-3	SL-4
Landslide Hazard	Topography	Visibly recognized	Visibly recognized	Visibly recognized	Not visible
	Mass, body	Recognized	Recognized	Recognized	Not recognized
	Size (approx.)	Block 1A: 100 m (w) x 120 m (L) Block 1C: 100 m (w) x 75 m (L)	Block 2A: 20 m (w) x 30 m (L)	Block 3A: 150 m (w) x 150 m (L) Block 3A1: 75 m (w) x 70 m (L)	–
	Depth (thickness)	10 – 15 m	3 – 5 m	10 m	–
	Geological mechanism	Bedding-slip of loosened bedrocks with talus deposits (Dip-slip structure)	Bedding-slip of thin bedrock blocks (Dip-slip structure)	Bedding-slip of loosened bedrock with talus deposits (Dip-slip structure)	–
	Groundwater	GL -3 m	GL -20 m (or below)	GL -25 m	GL -30m (or below)
	Spring water	Much in rainy season	Rare	Much in rainy season	Partially in rainy season
	Visible Deformation	Many confirmed	Unstable rock mass	Many confirmed	Confirmed
	Possible trigger	Heavy rain, earthquake	Heavy rain, earthquake	Heavy rain, earthquake	–
	Strain Measurement	Not active (as of Jan 25, 2008)	–	Not active (as of Jan 25, 2008)	Not active (as of Jan 25, 2008)
Related hazards		Slope failure on cut slope (frequent)	Rock fall (sometimes)	Slope failure on cut slope (sometimes)	Slope failure on cut slope (Block 4A) (rare–sometimes)
Evaluation (Impact to Highway)		High* *Most dangerous landslide	Low* *Size is small	Moderate* *Slope failures widening	Low* *Seems to be stable

L: length, w: width ☐: Countermeasure target. The evaluation is based on a study results as of February 18, 2008.

3.3 Risk Assessment of Road Slope Disasters

3.3.1 Outline of Risk Assessment

Road slope disaster risk is evaluated using two risk indicators in this report. One is the frequency of road closure disaster of a site (FRCDp) while the other is potential annual loss of the site (ALp).

Relation of FRCDp and ALp is shown in Figure 3.3.1 below.

FRCDp: frequency of road closure disaster of a site [RCD/ year]

Lp: potential loss of a road closure disaster [Rs/RCD]

ALp = FRCDp x Lp

ALp: potential annual loss [Rs/year]

RCD: Road closure disaster

Figure 3.3.1 Relation of Risk Indicators

In general, risk is considered as the product of frequency and magnitude. FRCDp is an index which only shows the frequency element of risk. ALp is the overall index which is the product of frequency and the magnitude of risk, evaluated as monetary loss.

(1) Potential Frequency of Road Closure Disaster of a site (FRCDp)

Estimated structure of FRCDp is shown in Figure 3.3.2.

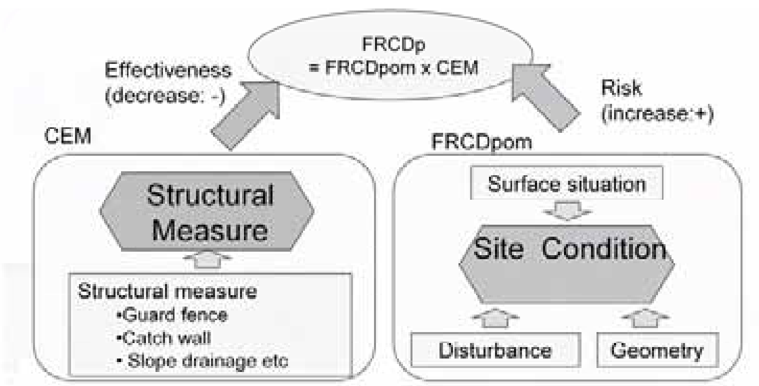


Figure 3.3.2 Estimation Structure of FRCDp

Geometry, surface situation and disturbance are FRCDp factors in the absence of existing measures (FRCDpom). On the other hand, effect of existing structural measures is defined as the coefficient of effectiveness of existing structural measures (CEM). FRCDp is estimated as the product of FRCDpom and CEM.

(2) Potential Annual Loss of a Site (ALp)

Estimation structure of FRCDp is shown in Figure 3.3.3.

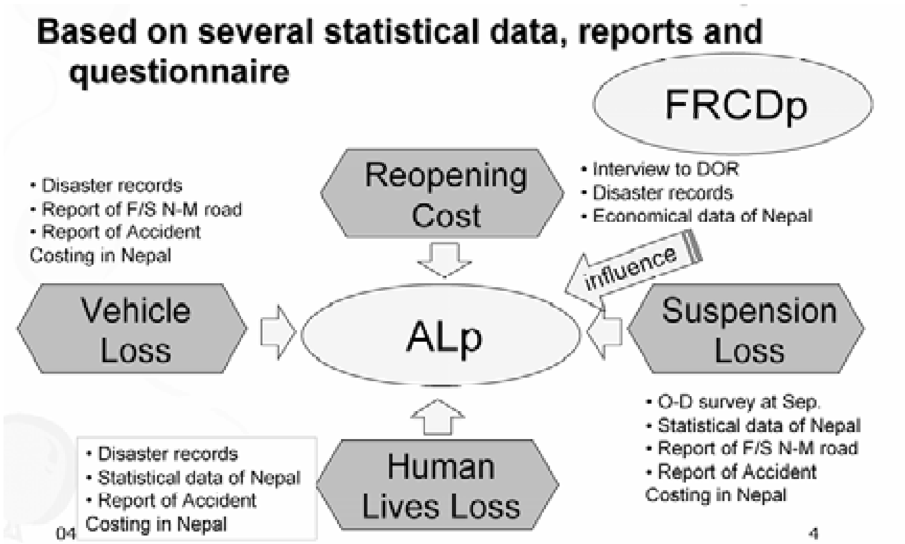


Figure 3.3.3 Estimation Structure of Annual Losses

ALp is the product of FRCDp and potential loss of a site (Lp) as previously mentioned. Lp is composed of four elements consisting of reopening cost, human lives loss, vehicle loss, and suspension loss. Suspension loss is caused by impassable road site, which is composed of losses of waiting, detour, and cancellation.

3.3.2 Workflow

Figure 3.3.4 shows flow of assessment of risk and feasibility of structural measures on N-M Highway.

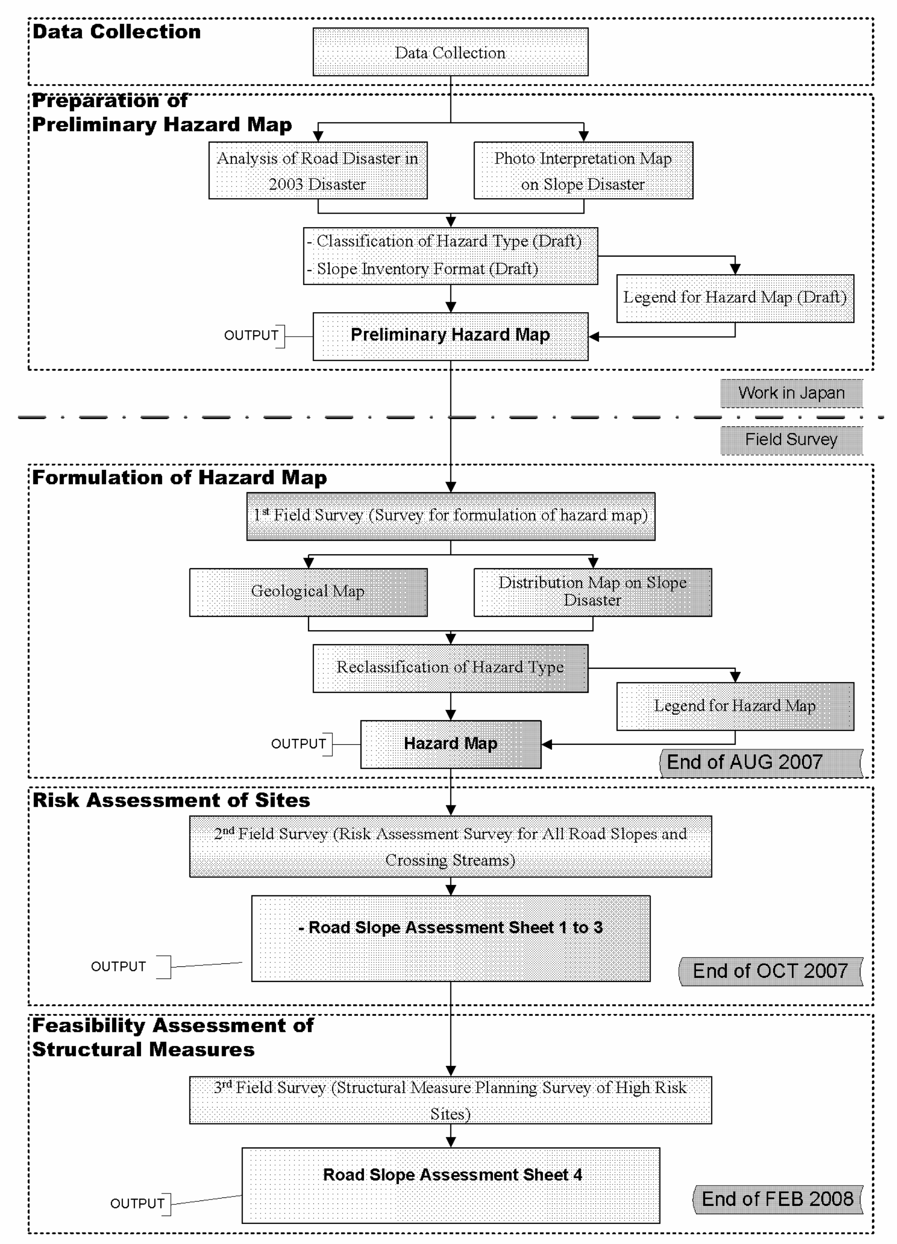


Figure 3.3.4 Flow of Road Slope Assessment on N-M Highway

Hazard map is used as part of input information for risk assessment of sites (road slopes and road crossing streams).

3.3.3 Road Slope Assessment Sheet

Assessment sheet for risk & feasibility of structural measures (excel spread sheets) are prepared. Figure 3.3.5 shows the flowchart of road slope assessment sheet.

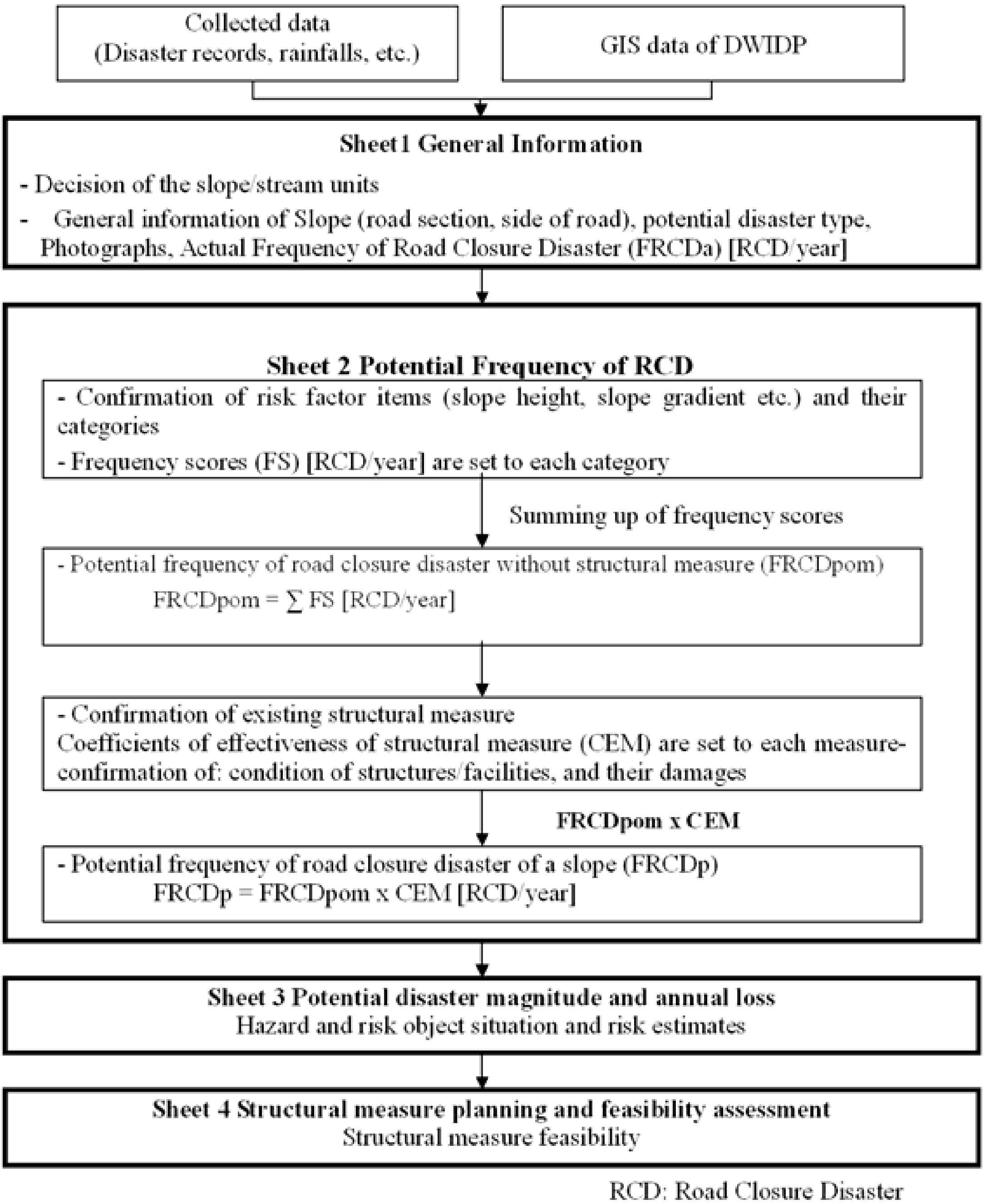


Figure 3.3.5 Flowchart for Assessment of Risk and Feasibility of Structural Measures

Table 3.3.1 shows items required for the assessment of risk and feasibility of structural measures.

Table 3.3.1 Items in the Assessment Sheet for Risk and Feasibility of Structural Measures

Sheet No. Name (contents of work)	Description/data
Risk Assessment of Sites	
Sheet 1. General Information (Screening/ identification of sites to be surveyed)	- Location of site (km post, right/left of road, expected hazard type) - Photographs of site (slope/stream) situation - FRCDa: Actual frequency of RCD of a site [RCD/ year] -FRCDabm: Actual frequency of RCD before structural measures of a site [RCD/year]
Sheet 2. Potential Frequency of RCD (FRCDp) (Disaster frequency assessment)	- Check sheet of hazardous factor items and their categories (item groups are geometry, surface situation, and disturbance), and existing structural measures. - Evaluation results of disaster frequency FRCDpom: FRCDp without existing structural measures [RCD/year] CEM: Coefficient of Effectiveness of structural Measures [ratio] FRCDp: Potential Frequency of RCD [RCD/year] = FRCDpom x CEM
Sheet 3. Potential Disaster Magnitude and Annual Loss (Disaster magnitude identification and risk estimation)	- Sketch of hazard situation and risk object - Evaluation of disaster magnitude LRCpoF: potential Length of Road Closure section of Full width [m] LRCpoP: potential Length of Road Closure section of Partial width [m] - Evaluation of annual losses RCp: potential reopening cost of a RCD HLLp: potential value of human lives loss of a RCD VLp: potential value of vehicles loss of a RCD LTSp: Potential Value of Losses of Traffic Suspension of a RCD Lp: potential loss of a RCD ALp: potential annual loss of a site
Feasibility Assessment of Structural Measures of Sites	
Sheet 4 Planning of Structural Measures (planning of structural measure and feasibility assessment) 4-1 Alternative I High risk reduction 4-2 Alternative II Medium risk reduction 4-3 Alternative III Low risk reduction	- Plane layout of structural measures - Section layout of structural measures - Cost C: cost estimation with 20 years maintenance [Rs] - Benefit /outcome RRR: risk reduction ratio in RCD due to structural measures [Ratio] DAL: Decrease in annual loss due to structural measures [Rs/year] FRCDpwm: Potential frequency of road closure disaster with structural measures [RCD/year] -Feasibility Indicators BCR: Benefit/cost ratio at 12% discount rate [ratio] ENPV: Economic net present value at 12% discount rate [Rs] EIRR: Economic internal rate of return [percent]
Disaster Record	
Sheet 5 Disaster Record (records of when disasters occur after the Inventory Survey)	- Disaster occurrence date - Disaster magnitude - Damage: road closure days, reopening cost, human loss if any, vehicle loss if any - Existing countermeasures

RCD: Road closure disaster

3.4 Results of Risk Assessment

3.4.1 Narayangharh-Mugling Highway

(1) Risk Level of Sites

The Team carried out road slope disaster risk assessment survey along N-M highway in August 2007 with the local staff of DWIDP and DOR. The risk of 305 sites (134 mountainside slopes, 78 crossing streams, and 93 riverside slopes) were assessed using the road slope disaster assessment sheets, mentioned in section 3.3. Risk level indicators for the assessment are as follows:

- Potential frequency of RCD of a site (FRCDp) [RCD/year]

- Potential annual loss of a site (ALp) [Rs/year]

Potential disaster sites are distributed along chainage 10 km to 36 km (26 km length section) of the N-M highway. High risk level sites (FRCDp is over 0.1 RCD/year, or ALp is over 1.0 million Rs/year) are scattered entirely along the 26 km stretch of the highway. Among the three slope-types (mountainside slope, crossing stream slope, and riverside slopes), the mountainside slope has the most risky.

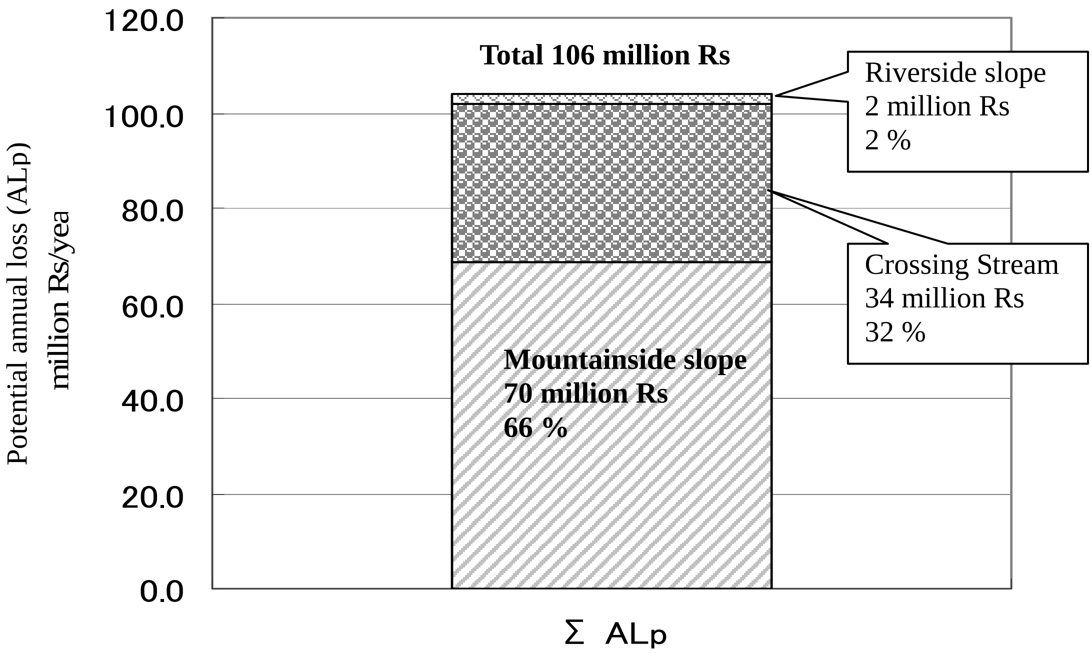


Figure 3.4.1 Potential Annual Loss (ALp) on N-M Highway by Slope Type at 2007 Value

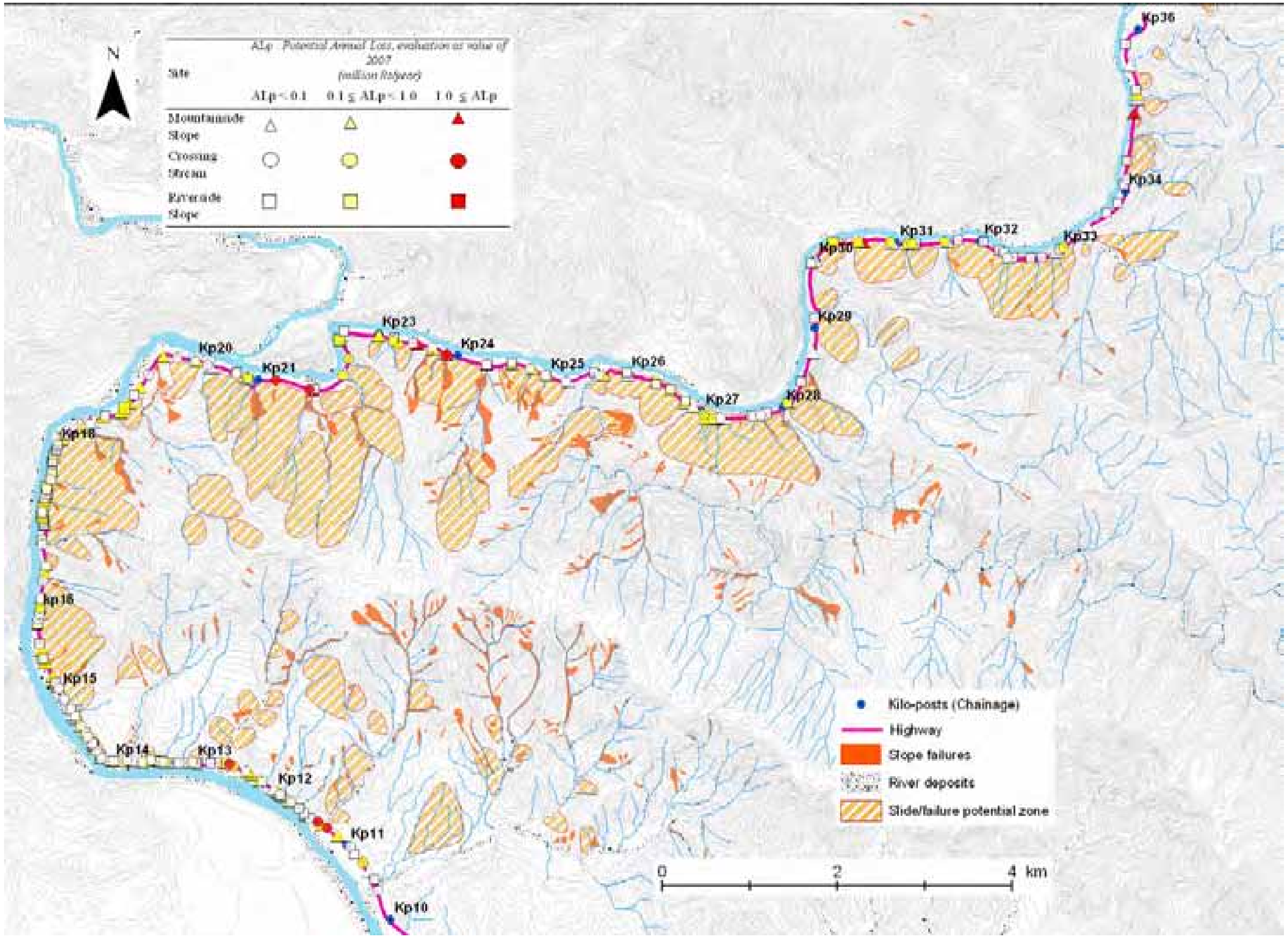


Figure 3.4.2 Potential Annual Loss of a site (ALp) with Hazard

(2) Total Risk of Narayangharh-Mugling Highway

The highway section which has risk of RCD is between chainage 10 km and 36 km of N-M Highway.

A total of 106.1 million Rs/year of annual loss is predicted based on 2007 market value. Proportions of the ALp by slope-type are: 65.9% of mountainside slope, 32.1% of crossing stream and 2.1% of riverside slope. The proportion of potential annual loss caused by traffic suspension (ASLp) is considerable with 99% of the total ALp (Figure 3.4.1). Figure 3.4.2 shows categorized ALp levels of sites on hazard map.

(3) High Risk 12 Sites

The risk level of slopes and stream are classified into three categories, using ALp ranking as indicator (mil. Rs/year), shown in the Table 3.4.1. Table 3.4.2 lists 12 high risk sites where ALp is over 1.0 million.

Table 3.4.1 Classification of Risk Level by Alp as of 2007

Rank of ALp (mil. Rs)	Mountain side Slopes			Crossing Stream			Riverside Slope			Total		
	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)
0-0.1	61	0.4	1	54	0.4	1	87	0.0	2	202	0.9	1
0.1-1.0	67	41.6	60	18	11.1	33	6	2.1	98	91	54.8	52
1.0<	6	27.9	40	6	22.5	65	0	0	0	12	50.4	47
Total	134	69.9	100	78	34.0	100	93	2.1	100	305	106.1	100

Table 3.4.2 Twelve High Risk Sites where ALp is over 1.0 Million

Chainage of starting side	Slope-type	Disaster Type	FRCDp (RCD/year)	ALp (mil. Rs/year)
11 km 280 m (Kahale Kola)	Crossing stream	Debris flow	0.25	5.8
11 km+500 m	Crossing stream	Slope failure & debris flow	0.26	2.1
12 km+600 m (Das Kola)	Crossing stream	Debris flow	0.39	7.7
21 km+200 m	Crossing stream	Slope failure & debris flow	0.34	2.7
21 km+560 m	Crossing stream	Debris flow	0.13	1.3
21 km+610 m	Mountainside slope	Slide	0.15	2.9
23 km+510 m	Mountainside slope	Slide & slope failure	0.24	3.5
23 km+930 m	Crossing stream	Debris flow	0.23	2.3
23 km+960 m	Mountainside slope	Slide	0.24	13.7
24 km+235 m	Mountainside slope	Slide & slope failure	0.19	1.5
30 km+690 m	Mountainside slope	Slope failure	0.24	1.9
34 km+200 m	Mountainside slope	Rock fall	0.55	4.3
Total of 12 sites Percentage divided by total of all 305 sites			3.21 15%	50.4 47%
Total of all 305 sites			22.02	106.1

(4) Risk Level of Road Section for Every Kilometer

(a) General

For determining high risk road sections, risk level indicators for a site was processed for every kilometer of the road section as shown in Figure 3.4.3

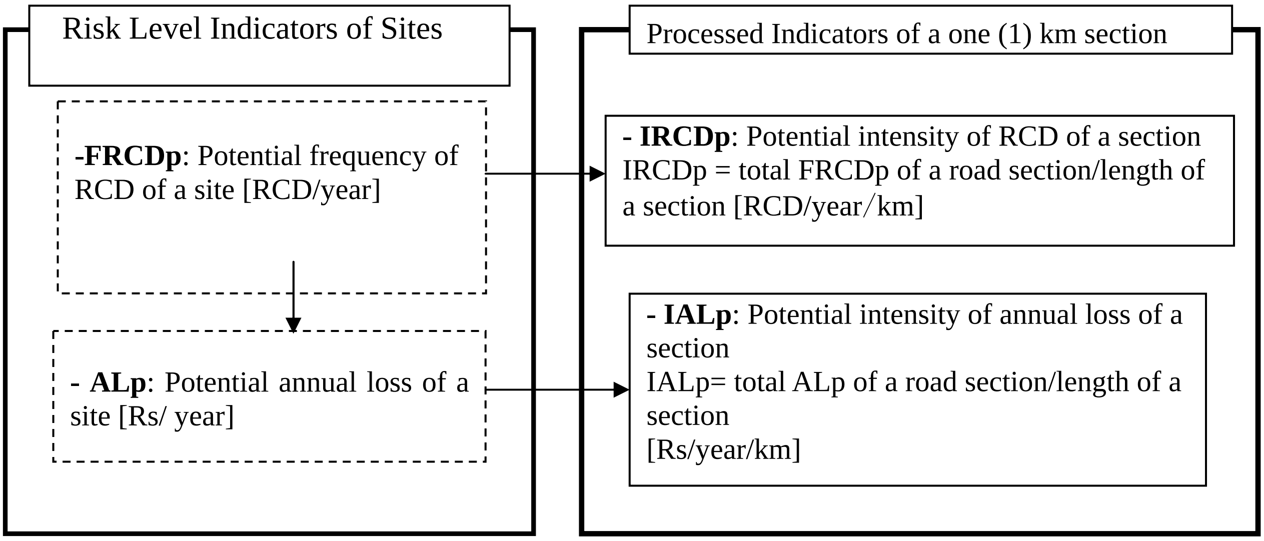


Figure 3.4.3 Processing of Risk Level Indicators of a Road Section

(b) Potential Intensity of Road Closure Disaster of a Road Section (IRCDp)

The IRCD of a road section is calculated by the following formula.

$$IRCDp = \sum FRCDp/LS$$

(c) Potential Intensity of Annual Loss of a Road Section (IALp)

The IALp is calculated by the following formula.

$$\mathbf{IALp = \sum IALp/LS}$$

(d) Risk Revel of One km Road Sections

Risk level indicators of road section at each kilometer are shown in Table 3.4.3.

High disaster frequency road sections, where IRCDp exceeds 1.0 [Nos. of RCD /year/ km] are: km 11-12, km 13-15, km 17-18, km 27-28, and km 34-35. High annual loss road sections, where IALp is higher than 10 million Rs/ km /year are: km 11-13, and km 23- 25.

Table 3.4.3 Outline of Risk along N-M Highway

km Section	IRCDp: Potential Intensity of RCD of a section	IALp: Potential Intensity of Annual Loss of a section	Top 12 ALp Sites
	RCD/km	Rs/km/year	
km 10 - km 11	0.20	636,349	
km 11 - km 12	**1.28**	**12,553,071**	2 sites
km 12 - km 13	***0.90***	**11,596,374**	1 site
km 13 - km 14	**1.28**	***5,532,572***	
km 14 - km 15	**1.26**	***3,907,911***	
km 15 - km 16	***0.73***	***2,629,073***	
km 16 - km 17	***0.93***	***2,509,015***	
km 17 - km 18	**1.76**	***6,125,221***	
km 18 - km 19	0.49	***2,560,350***	
km 19 - km 20	***0.62***	***3,139,973***	
km 20 - km 21	***0.84***	***2,878,446***	
km 21 - km 22	***0.84***	***8,443,483***	3 sites
km 22 - km 23	0.43	768,427	
km 23 - km 24	***0.94***	**11,427,335**	3 sites
km 24 - km 25	***0.93***	**14,584,536**	1 site
km 25 - km 26	***0.55***	***1,578,079***	
km 26 - km 27	***0.55***	***2,228,505***	
km 27 - km 28	**1.38**	*1,295,980*	
km 28 - km 29	***0.75***	488,570	
km 29 - km 30	***0.50***	18,536	
km 30 - km 31	***0.63***	***2,787,817***	1 site
km 31 - km 32	***0.91***	***3,025,898***	
km 32 - km 33	***0.85***	304,143	
km 33 - km 34	***0.73***	28,870	
km 34 - km 35	**1.07**	***4,369,938***	1 site
km 35 - km 36	***0.66***	685,373	
km 36 - km 36.1	0.09	3,417	
Average	***0.84***	***4,065,294***	

3.4.2 Ruwa Khola/ Marsyangdi Hydro Power Plant

(1) Policy and Flow of Risk Assessment

Hazard with same magnitude has occurred on 31st July 2003, the only one scenario which can be utilized to estimate values of frequency and magnitude of disaster. Consequently, risk is estimated based on this scenario in this study. Flow of risk assessment is shown in Figure 3.4.4.

Risk without existing structural measure

= Potential disaster frequency x Potential disaster magnitude [Rs/year]

Potential disaster frequency: same as return period of rainfall amount (24 hour rainfall amount) [disasters/year]

Potential disaster magnitude: same as loss by 31st July disaster in 2007 price [Rs]

↓

Risk with existing structural measure

= Risk without existing measure x CEM [Rs/year]

CEM: Coefficient of effectiveness of structural measure for disaster frequency [no unit]

Figure 3.4.4 Flow of Risk Estimation for Ruwa Khola/ Marsyangdi Hydro Power Plant

(2) Disaster Frequency without Existing Structural Measure

The frequency of the disaster is evaluated as the same value of the return period which 16 years of 24 hour rainfall amount, hence, frequency is 1/16 [disasters/year] as per Devghat rainfall gauge station. If the other calculation method of rainfall amount is selected such as the “modified rainfall amount of 6, 12, 24 hour half value”, a smaller return period (refer chapter 3) will be obtained. The 24-hour rainfall amount is therefore adapted as most conservative for the return period.

(3) Disaster Magnitude without Existing Structural Measure

Magnitude of monetary loss during the disaster that occurred on 31st July 2003 is estimated based on results of questionnaire survey on Mugling – Pokhara road conducted on February 2008 (national statistical data, and data form DOR and NER).

Results of monetary loss estimation are tentatively summarized in Table 3.4.4. The monetary losses are finalized and shown in the draft final report prepared on June 2008.

Table 3.4.4 Loss by disaster on 31st July in 2007 Price (Tentative)

Items	Loss (Rs)
Reopening cost (tentative detour road)	40,000
Loss of road and power plant	58,350,000
Loss of vehicle	40,000
Loss of power plant electricity	87,700,000
Loss by traffic Suspension (waiting, detour, and cancellation)	9310,000
Total	**155,440,000**

(4) Risk without Existing Structural Measure

Risk: Potential annual loss without existing structural measure is estimated by multiplying the disaster frequency with the disaster magnitude as follows:

Potential annual loss without existing structural measure

= Potential disaster frequency x Potential disaster magnitude [Rs/year]

where;

Potential disaster frequency: same as return period of rainfall amount (24 hour rainfall amount) [disasters/year] = 1/16

Potential disaster magnitude: same as loss by 31st July disaster in 2007 price [Rs]

= 155,440,000 [Rs/disaster] x 1/16 [disasters/year]

As a result, potential annual loss without existing structural measure is estimated as 9,715 Rs/year.

(5) Risk with Existing Structural Measure

Risk causing Potential annual loss with existing structural measure is estimated by multiplying of “potential annual loss without existing structural measure’’ and “coefficient of effectiveness of structural measure for disaster frequency (CEM)” as follows:

Potential annual loss with existing structural measure
= Risk without existing measure x CEM [Rs/year]
Where;
CEM: coefficient of effectiveness of structural measure for disaster frequency [no units]

Existing sabo dams have effectiveness of retaining the same scale debris flow of the hazard on 31st July 2003. But, in this site, the volume of debris generated due to slope failure is more than debris control volume of sabo-dams, while a part of existing flow sections is less than the flow section based on the rainfall intensity in 2003. Apart from this, the effectiveness of retaining debris in the sabo dams is reduced by the considerable volume of unstable debris deposited above these dams. Taking these things into consideration, CEM is set as “0.5”.

= 9,715,000 [Rs/year] x 0.5 = 4,875,000 [Rs/year]

Potential annual loss with existing structural measure is estimated
4,875,000 [Rs/year].

CHAPTER 4

BASIC STRATEGY

4.1 General

4.1.1 Policies on Formulation of Basic Strategy

The basic strategy on road disaster management for the N-M Highway is formulated by utilizing all the information related to disaster risk management for the target road section, which is obtained in the process of the Study as shown in the Figure 4.1.1.

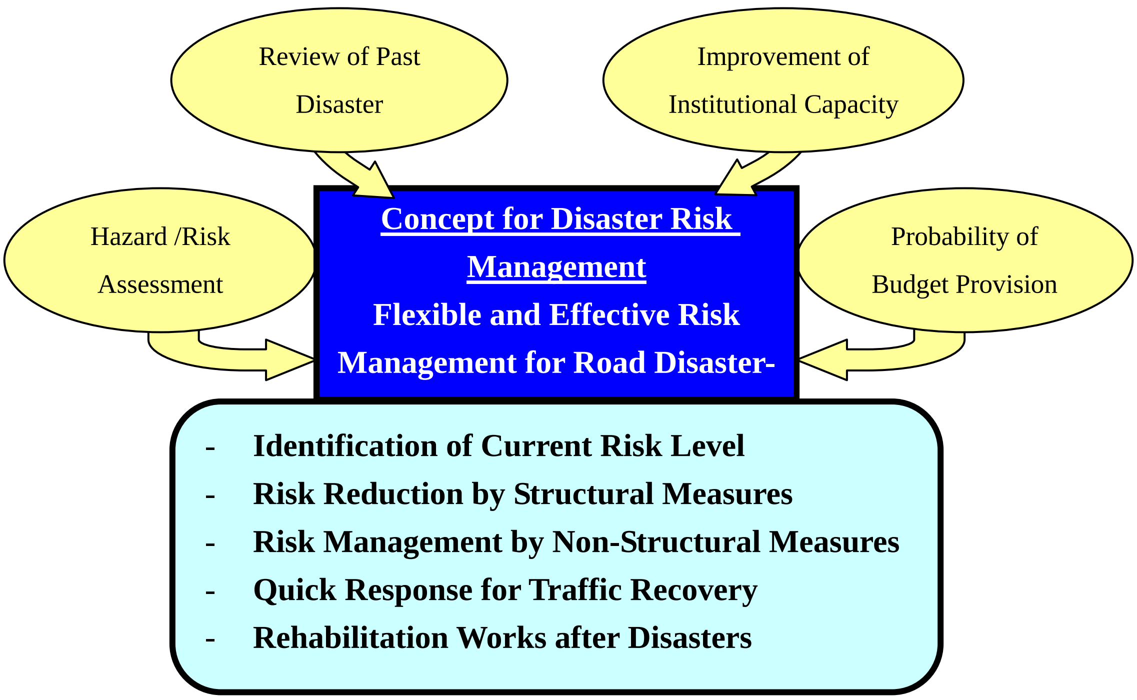


Figure 4.1.1 Concept Formulation of Disaster Risk Management

4.1.2 Identification of Current Potential Risk

Inventory survey has been carried out as described in the Chapter 3, in which, a total of 305 sites including 134 mountain side slopes, 78 crossing streams and 93 river side slopes have been surveyed to estimate the current risk induced by slope disaster.

Table 4.1.1 Risk before 2003 and At Present

Term	FRCDp (RCDs/year)	Ratio	ALp (mil. Rs/Year)	Ratio
Before 2003	34.7	100%	194	100 %
At Present (2007)	22.0	63%	106	55%

4.1.3 Policy to Plan Basic Strategy

Components of basic strategies are shown in Figure 4.1.2.

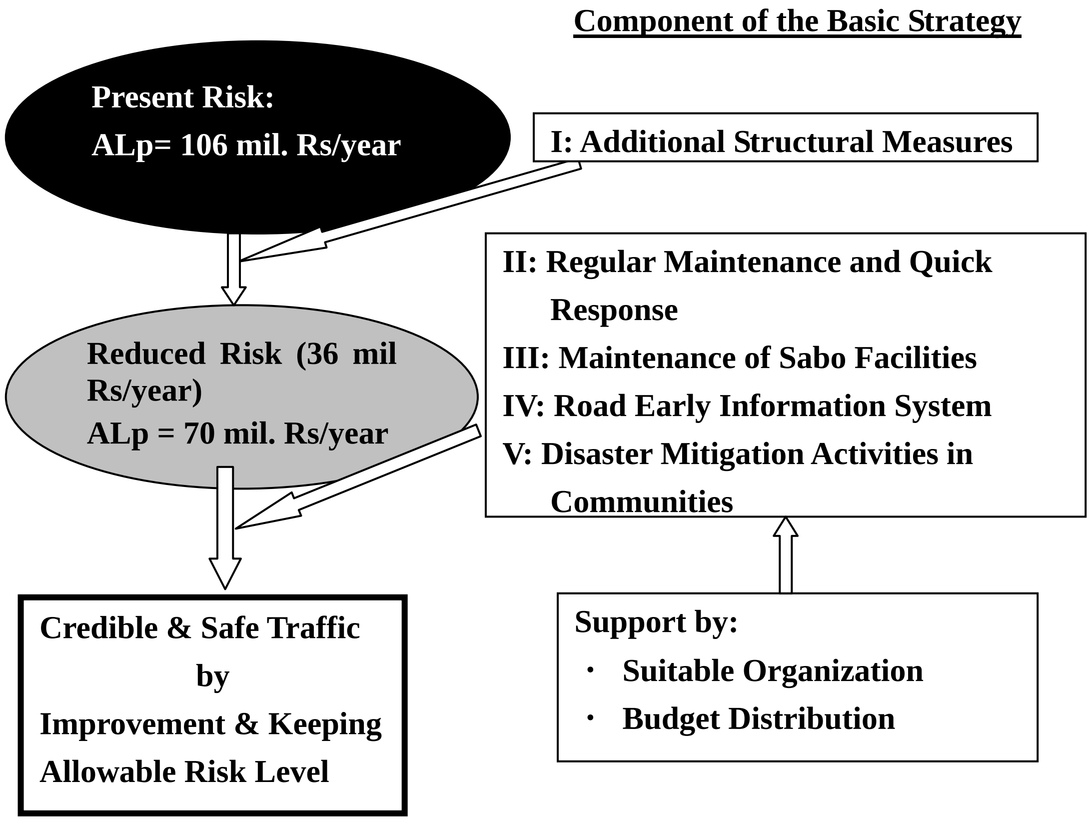


Figure 4.1.2 Components of the Basic Strategy and Risk Management

Each item of the Basic Strategy is described as follows:

1) Additional Structural Measures
2) Regular Maintenance and Quick Response
3) Maintenance of Sabo Facilities
4) Road Early Information System
5) Disaster Mitigation Activities in Communities

4.2 Additional Structural Measures

4.2.1 Target Setting

As described in Chapter 3, the risk level of slopes and stream can be classified into three categories using rank of ALp as indicator (mil. Rs/year) with values 0-0.1, 0.1-1.0, 0, These were related with Alp values of more than 1 million Rs/year as shown in the Table 4.2.1.

Table 4.2.1 Classification of Risk Level by Alp as of 2007

Rank of ALp (mil. Rs)	Mountain side Slopes			Crossing Stream			Riverside Slope			Total		
	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)	Nos.	ALp (mil. Rs)	Ratio (%)
0-0.1	61	0.4	1	54	0.4	1	87	0.0	2	202	0.9	1
0.1-1.0	67	41.6	60	18	11.1	33	6	2.1	98	91	54.8	52
1.0<	6	27.9	40	6	22.5	65	0	0	0	12	50.4	47
Total	134	69.9	100	78	34.0	100	93	2.1	100	305	106.1	100

Among three ranks of ALp, the rank of over 1.0 million Rs/year class twelve slopes occupies 47% of the total amount of ALp, which is 106 million Rs/year.

4.2.2 Selected Sites for Deliberation of Preventive Structural Measures

Selected sites include six mountainside slopes and six crossing streams. Preventive structural measures and economical evaluation were studied on these 12 sites.

4.2.3 Preliminary Design and Cost Estimation

Among the selected 12 sites, three which is supposed to be measured by DWIDP or through this pilot project and one more site which can be excluded since deposits in the sabo dam is removed. An additional site in Ruwa Khola is however considered. Hence, total cost of preventive structural countermeasure in the nine sites is 204 mil. Rs.

4.2.4 Implementation Plan

(1) Contract Packaging and Implementation Organization

Certain works have been recommended to be subjected to international competitive bidding (ICB) mainly for technical reasons. Accordingly, the work is suggested to be divided into three contract packages, as shown in Table 4.2.2.

Table 4.2.2 Arrangement of Selected Sites for Implementation

Package	Location	Works	Cost (mill.Rs)	Implementation organization
1	21km+200	・ Catch wall + Protection fence	1.04	DWIDP (LCP)
	21km+610	・ Horizontal drain holes	6.48	
	23km+930	・ Gabion mat + Removal of deposit	1.82	
	24km+235	・ Horizontal drain holes work	2.00	
	Sub-total		**11.34**	
2	23km+510	・ Crib with rock bolt + Vegetation	29.63	DOR (ICP/LCP)
	23km+960	・ Crib with rock bolt + Vegetation	142.05	
	30km+690	・ Crib work + Vegetation	13.70	
	34km+200	・ Rock fall prevention net	6.98	
	Sub-total		**192.36**	
3	Ruwa Khola	・ Guide concrete wall	**18.37**	
Total			**222.07**	

Package 1 and 3 will be constructed by local contractors. Package 2 will be implemented under both ICB and Local Competitive Bidding (LCB) because it includes some techniques that are not common to local contractors in Nepal.

(4) Construction Schedule

Figures 4.2.1 and 4.2.2 show the overall construction schedule for Package I/III and Package II, respectively.

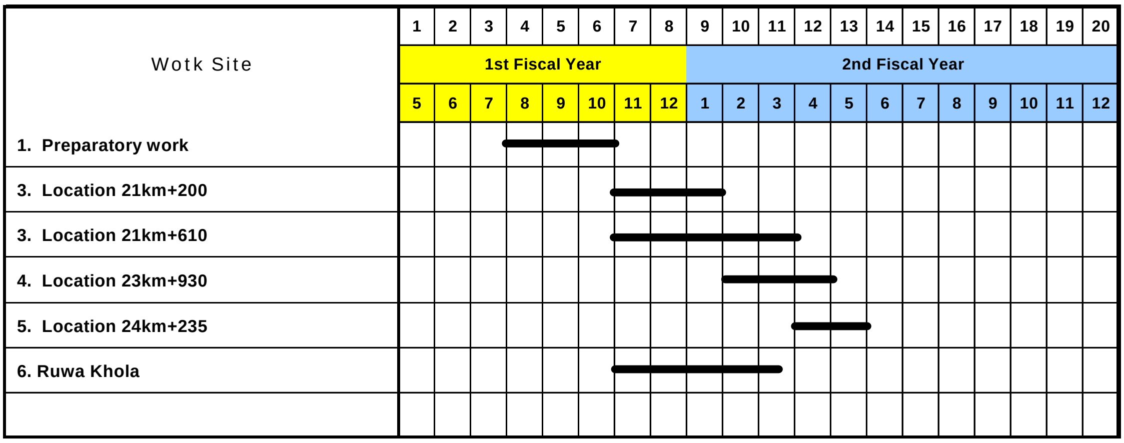


Figure 4.2.1 Overall Construction Schedule for Package I and III

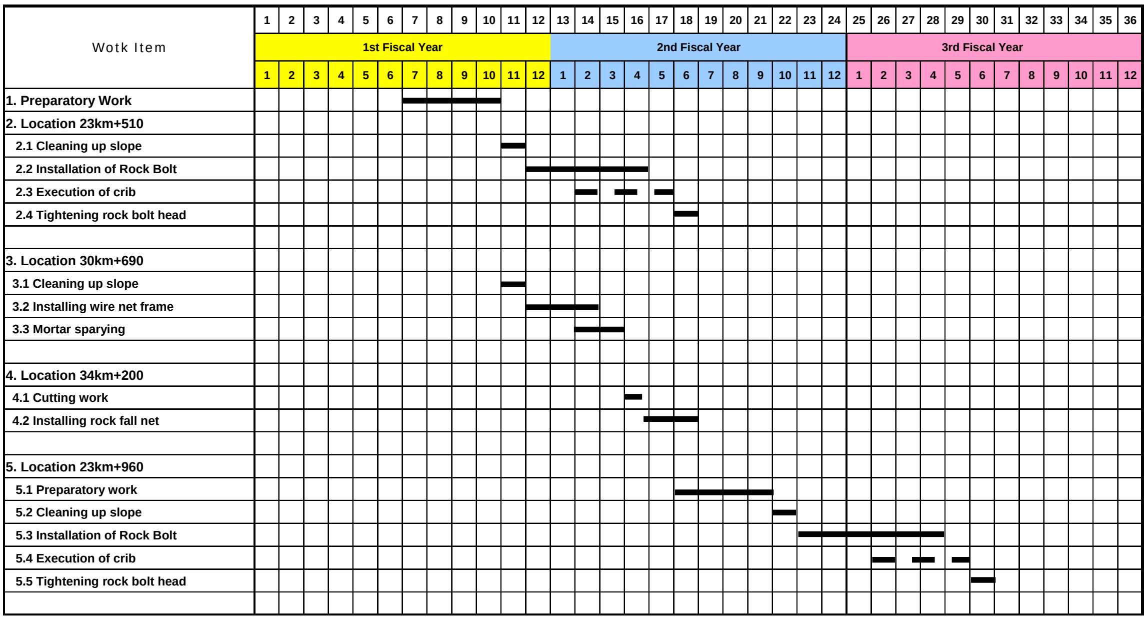


Figure 4.2.2 Overall Construction Schedule for Package II

4.3 Regular Maintenance and Quick Response

4.3.1 Road Maintenance along with Annual Plan

Road maintenance works on sediment related disasters including routine maintenance and emergency maintenance for N-M Highway is executed by the Division Roads Office (DRO), Bharatpur along with the "Annual Road Maintenance Plan" prepared in February 2008.

4.3.2 Activities and of Maintenance and Requested Budget

(1) Annual Cost

Activities and requested budget of maintenance works for N-M highway is planned as shown in the Table 4.3.1

Table 4.3.1 Planned Maintenance Works for N-M Highway

Maintenance Item	Budget Requested for 2008/2009 (Rs)
(a) Routine Maintenance	330,139
(b) Recurrent Maintenance	12,850,000
(c) Rehabilitation Works	11,594,822
(d) Bio-engineering & Other Works	36,897
(e) Emergency Works	393,209
Total (request base)	25,205,067

(Source; Annual Road Maintenance Plan (Draft/Request) forF.Y.2008/2009)

(2) Economic Evaluation on Maintenance Works

Relation between cost and benefit of the maintenance works are summarized in Table 4.3.2. Rationalization of emergency works can further reduce potential annual loss by shortening the duration of road closure.

Table 4.3.2 Cost and Benefit of Maintenance and Emergency Works

Cost Requested for 2008/2009 (Rs)	Annual benefit 2009 (Rs)		Benefit Cost Ratio
Maintenance			
Routine Maintenance 330,139 Recurrent Maintenance 12,850,000 Rehabilitation Works 11,594,822 Bio-engineering 36,897	Upkeep benefit of road condition		5.2
	1. Benefit by reduction of vehicle operation cost ＝10% of vehicle operation cost of a vehicle of the N-M highway x annual nos. of vehicles	115,178,835	
	2. Benefit by reduction of travel time ＝10% of travel time of a vehicle of the N-M highway x Unit value of traffic time of a vehicle x annual nos. of vehicles	30,091,641	
Total 24,811,858	Total	145,270,477	
Emergency Works			
393,209	50% of potential annual loss of traffic suspension (Rs 105,109,585)	52,554,793	134

4.3.3 Recommendation on Road Maintenance Works

(1) Sites necessary to take special attention in routine maintenance

Locations and viewpoints taken with special attention for sites are shown in the Table 4.3.3.

Table 4.3.3 Sites Need Attention in Seasonal inspection

Location	Disaster Type	Hazard Condition/Check Points
26km+700	landslide	continuous cracks by landslide movement on the road
27km+050	landslide	continuous cracks by landslide movement on the road
Anchor installation locations Sta24+025, Sta24+600 etc	sinking of embankment	

(2) Utilizing of Road Early Information System for Emergency Works

Reopening works or soil removal in emergency works is being carried out by Mugling camp, Gajuri camp, and Naubise camp, where heavy machines for soil works are deployed. Heavy machines of the camps are not sufficient for serious slope disasters, hence, machines shall be used efficiently. Monitoring by automatic raingauge suggests probability of occurrence of road slope disasters. It is recommended to prepare urgent response team when value reaches 12-hour half- rainfall amount = 60mm (One year return period). Earlier preparation and flexible operation of machines in three camps hastens reopening of road works.

It seems that recording and compilation of road maintenance is not systematic. Recording of maintenance works is very important especially for disaster management in order to prepare a reasonable and practical annual ,maintenance plan. It is recommended that a recording system for the road maintenance works is prepared, especially for the reopening and rehabilitation works.

4.4 Maintenance of Sabo Facilities

Mugling – Narayangharh Water Induced Disaster Prevention Project (MNWIDPP) implemented under DWIDP involves construction of sabo dams since 2004 in crossing streams that affect N-M Highway. Effectiveness of these facilities has been demonstrated during the 2006 heavy rainfall when no serious traffic disturbance happened. However, dams had been filled up with deposits due to this heavy rainfall, consequently deteriorating function of the sabo dams.

It should be noted that maintenance works of sabo facilities is very important to maintain the intended traffic flow along the highway.

4.4.1 Implementation organization

The implementing organization for maintenance works for sabo dam is DWIDP.

4.4.2 Major Maintenance Works of Sabo Dams

In order to maintain the functions of the existing sabo dams, the following two plans should be implemented:

- Removal of deposits
- Repair of damaged sabo facilities

4.4.3 Flow of Maintenance Works of Sabo Dams

Maintenance works of sabo dams are executed in accordance with the flow chart shown in Figure 4.4.1.

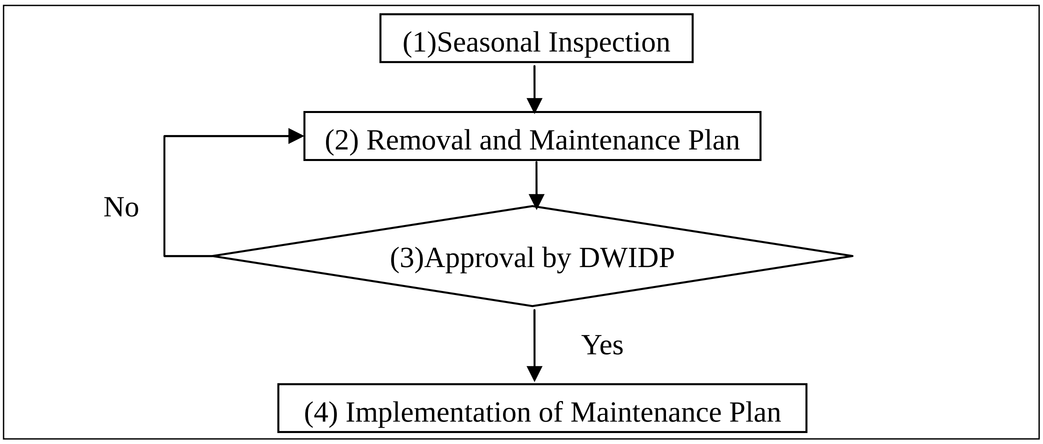


Figure 4.4.1 Flow of Maintenance Works for Sabo Dams

4.4.4 Outline of Removal of Deposits

(1) Selection of priority crossing streams

Sabo dams subjected to removal of deposits are shown in Table 4.4.1 while Figure 4.4.2 shows the concept of the functional recovery of existing sabo dams.

Table 4.4.1 Sabo Dams Needed to Remove Deposits

Location (km)	Nos. of Dams	Rough Estimated Volume (m^3)		Potential annual loss of 2007 (Rs/year)
		A	B	
11+200 (Kahale. K)	2	16,080	0	577,413
12+600 (Dash .K)	2	7,500	0	766,056
15+033	2	90	30	6,090
17+350	3	360	130	9,441
20+800	2	10	0	970,879
21+560	3	8,350	2,000	1323,536
23+150	3	30	0	866,764
23+710	2	300	50	63,147
23+930	10	2,030	700	685,683
24+740	2	240	80	7,000
24+960	3	460	170	7,768
27+195	2	40	0	236,800
27+705	2	100	0	11,181
27+900	1	400	0	463,733
Total 14 sites	39 dams	39,150		10,962,000
6 priority sites of remove deposits	22 dams	36,700		5,190,331

Notes: 1) A: Removal of unstable deposit, B: Removal of deposits to increase capacity
2) Potential annual loss of 11+ 280 (Kahale. K) and 12+600 (Dash. K) are values of after sabo works conducted by DWIDP from 2007 to 2008.

Six sites which potential annual loss of 2007 are over 0.5 mil. Rs/year progress the sedimentation of sand/debris. After 10-year risk (potential annual loss) will be two times of the present which is over 1.0 mil. Rs/year. Hence, the six sites are prioritized for the removal of deposit.

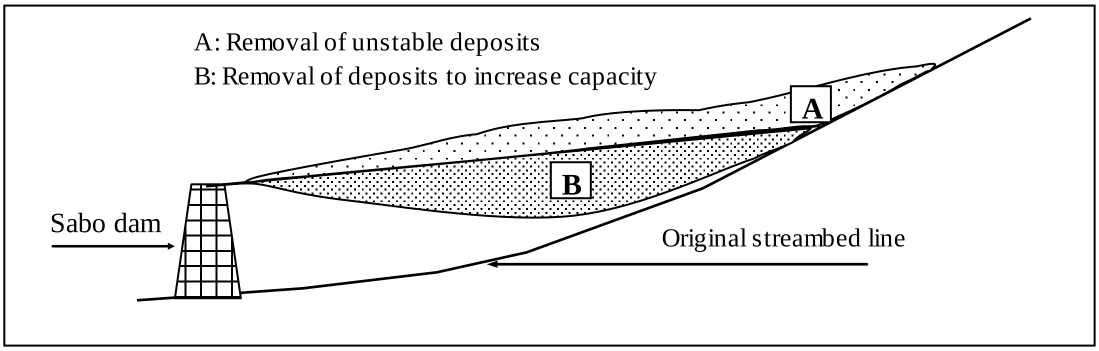


Figure 4.4.2 Conceptual Illustration of Functional Recovery for Sabo Dam

(2) Economic Evaluation

Sand removal is planned for the six priority sites which cross streams once every ten years. Amount of deposit is 36,700 m^3 of the six crossing streams. Annual cost is determined as follows:

Deposit removal cost is 1.0 mil Rs/year (280 Rs/ m^3)

Annual benefit is estimated as 1/4 of potential annual loss and 1.3 mil. Rs/year, because benefit of the after deposit removal is 1/2, but which is zero in ten years. Since annual benefit is bigger than the annual cost, the programme is determined economically feasible.

4.4.5 Repair of Sabo Facilities

Inventory survey on sabo facilities along N-M highway was carried out under MNWIDPP in the first half of 2008. A total of 251 facilities including concrete sabo dams, gabion check dams catch drainages, retaining walls, spurs, toewalls/chute/cascade, horizontal drainage and bioengineering works were surveyed.

It was found during the survey that six facilities were already damaged, 14 facilities lost their have totally become non-functional and thirty 39 are potentially loosing their preventive function. For these facilities, annual maintenance plan shall be implemented in order to retain their preventive purpose.

4.5 Road Early Information System

4.5.1 Purpose

The objectives of formulation of the Road Early Information System are：

- To prevent loss of human lives as well as vehicles subjected to road slope disasters,

- To reduce traffic congestion by disseminating early road information to drivers.

4.5.2 Target Area

Although target areas of the proposed system are to limited N-M Highway, this can contribute to connecting key areas such as Birgunji, Hetauda, Naubise, Pokhara, Butwal, etc in terms of traffic management.

4.5.3 Outline of the System

(1) General System

Road Early Information System was formulated as shown in Figure 4.5.1.

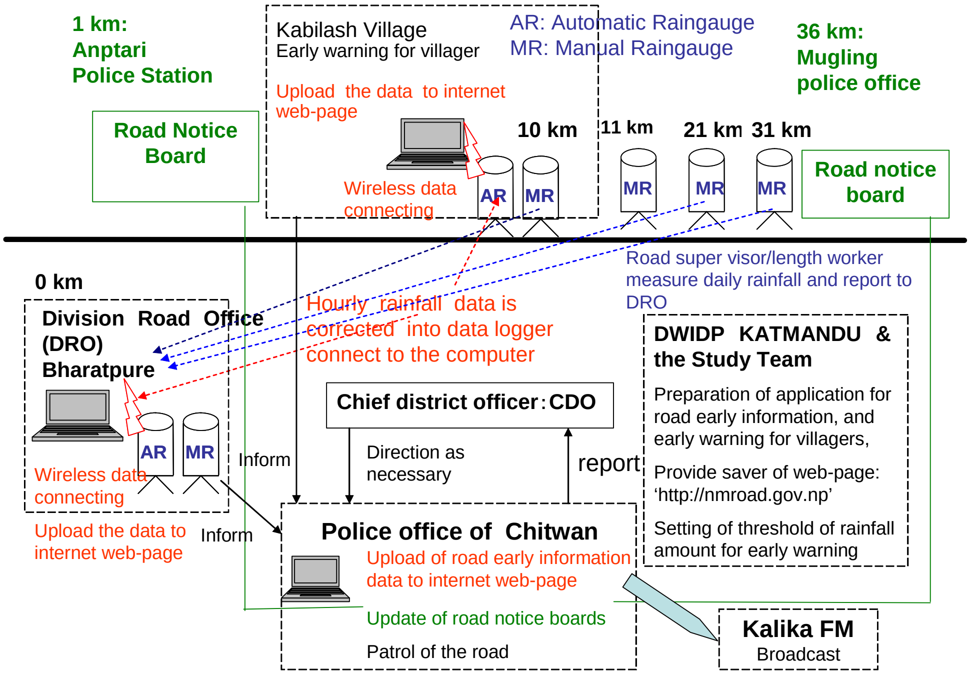


Figure 4.5.1 Schematic Chart of Formulated Road Early Information System

(2) Notice Board

Two notice boards were installed to provide drivers with traffic information on the condition of N-M Highway. It is intended to advise road users on the traffic situation along the roads that they need to pass through.

(3) Criteria and Action for Each Risk level

Criteria for determining traffic issues such as slope/water-induced disasters, traffic accident and strikes etc. are proposed as shown in Table 4.5.1. Corresponding actions to each level are also presented. These criteria will be revised accordingly depending on the changes of social situation and after conducting analysis of the relationship between rainfall data and disaster records.

Table 4.5.1 Threshold of Early Warning by Modified Rainfall Amount

Warning Level	Threshold of rainfall	Action
		For road User
Level IV	12 hour half-value rainfall amount =180mm Ten (10) year return period	**Warning Notice:** Recommendation to avoid traffic on the road
Level III	12 hour half-value rainfall amount =140mm Five (5) year return period	**Caution Notice:** Recommendation to careful passage on the road
Level II	12 hour half-value rainfall amount = 80mm Two (2) year return period	Same as Level I
Level I	12 hour half-value rainfall amount = 60mm One (1) year return period	**Set into preparation** Start patrol, call up staff/workers/equipment for emergency action Checking/upload to web-page of modified rainfall amount one hour each

(4) Monitoring of Raingauge

Method of raingauge monitoring, carried out by DRO and Kabilash VDC, are as follows:

(a) Automatic Raingauge

Monitoring of the automatic raingauge is carried out in the following manner:

- 12 hour rainfall amount is less than 60mm: checked once a day
- 12 hour rainfall is over 60mm: check every time

(b) Manual Raingauge

Monitoring of manual raingauges is performed once a day.

(5) Monitoring of Traffic Condition

Traffic incidents, road blockade by strike, abnormal condition of the road and road slopes are reported by drivers and pedestrians to DPO and DRO.

4.5.4 Organization Formed to Operate the System

(1) Tasks of Chitwan District Disaster Management Partnership Committee

- Decide on methods of disseminating traffic information
- Discuss and determine risk level and information criteria
- Preparation of manuals and leaflets regarding the system
- Public relation on Road Early Information System through the press and mass media

(2) Roles of Concerned Major Organizations

1) CDO

2) DPO

- Superintendent of Police (SP) of DPO recommends deciding the appropriate public notice for risk level III (Caution Notice) and risk level IV (Warning Notice).
- After decision is made for risk levels III and IV, SP orders the traffic police to display advise on the notice board
- Upload the early warning/traffic condition to the web page
- Inform traffic condition to Kalika FM
- Maintenance of computer
- Instruct drivers on matters of traffic control policy and conduct

3) DRO

- Monitors and maintains designated devices namely, five raingauges and a computer
- Analyzes monitoring data to determine the time to post notice regarding risk levels III and IV
- Reports to DPO regarding rainfall monitoring and analyzed results, and recommends posting risk level III and IV notice.

4) Kabilash VDC

- Monitors and maintains designated devices namely, four raingauges and a computer
- Analyzes monitoring data to determine the time to post notice regarding risk levels III and IV
- Reports to DPO regarding rainfall monitoring and analyzed results and recommends posting risk levels III and IV notice

5) DWIDP, MNWIDPP and/or Division No.3 office

- Formulate/revise Road Early Information System on road slope disaster
- Support Kabilash Village in monitoring rainfall

4.5.5 Cost and Economical Evaluation of the System

(1) Cost

Cost of the system in 20 years from 2008 is shown in Table 4.5.2. Annual cost is 150,000 Rs/year. Cost for required staff is not included in the table.

Table 4.5.2 Cost of Road Early Information

Item	Unit cost	Quantity	Cost (Rs)	Cost per year (Rs/year)
Initial cost				
Computer	79,100	3	237,300	
Microsoft Office	40,115	3	120,345	
Virus Security	8,625	3	25,875	
UPS	45,200	3	135,600	
CDMA Phone	22,600	3	67,800	
Soft Development	226,000	1	226,000	
Automatic Raingauge	203,400	2	406,800	
Manual Raingauge	22,600	4	90,400	
Road notice board	220,350	2	440,700	
Total of initial cost			1,750,820	
Operation Cost				
Maintenance for 20 years 50% of initial cost			875,410	43,771
Communication fee of CDMA phone for 20 years (500 Rs/month)	120,000	3	360,000	
Total			2,986,230	149,312

(2) Benefit

Table 4.5.3 Benefit of Road Early Information System

Item	Benefit (Rs/year)
50% reduction of potential annual loss of human lives	3,618
50% reduction fof of potential annual loss of vehicles	7,920
10% of related cost due to traffic congestion	10,510,959
Total	10,555,497

4.6 Disaster Mitigation Activities in Communities

4.6.1 Purpose

The objectives of disaster mitigation activity in communities are to:

- Mitigate the hazard condition of the higher portion of the slopes which are affecting occurrence of debris flow and landslide,
- Reduce casualties caused by slope/water induced disasters by initiating Early Warning/ Evacuation System.
- Formulate system on self and mutual assistance for disaster mitigation

4.6.2 Target Area

The target area is the Kabilash Village, especially portion of wards 1, 2, 3, 4, 5, 6, 8, 9 that are facing the highway and threatened by sediment-related disasters.

4.6.3 Outline of Disaster Mitigation Activities in Kabilash Village

1) Hazard mapping
2) Disaster education
3) Early Warning/ Evacuation System
4) Simple structural measures
5) Forestation planning and countermeasure planning

4.6.4 Cost of the System and Economic Evaluation

(1) Cost

Cost of early warning/evacuation system in 20 years from 2008 is shown in Table 4.6.3. Annual cost is 43,000 Rs/year. Cost for required staff is not included in the table.

Table 4.6.1 Cost of Early Warning/ Evacuation System

Item	Unit cost	Quantity	Cost (Rs)	Cost per year (Rs/year)
Initial cost				
Computer	79,100	1	79,100	
Microsoft Office	40,115	1	40,115	
Virus Security	8,625	1	8,625	
UPS	45,200	1	45,200	
CDMA Phone	22,600	1	22,600	
Automatic Raingauge	203,400	1	203,400	
Manual Raingauge	22,600	1	22,600	
Total of initial cost			421,640	
Operation Cost				
Maintenance for 20 years 50% of initial cost			210,820	10,541
FM radio broad casting			100,000	5,000
Communication fee of CDMA phone for 20 years (500 Rs/month)	120,000	1	120,000	
Total			852,460	42,623

(2) Benefit

Benefit of early warning/evacuation system is attributed to 50% reduction of potential annual loss of human lives due to water induced-induced disasters. In Kabilash village, 21 persons died in the past 10 years (1998 -2007) due to such disasters. Average rate of potential annual loss of human lives is 2.1 person/year, which is equivalent to 1,415,400 Rs/year considering human life value of 674,000 Rs/person. Benefit from the system is 50% of this cost which is 707,700 Rs/year. The benefit is bigger than the anticipated cost.

4.7 Organization and Institutional Plan/Budget Planning

4.7.1 Organization in Charge

The program and organization for the basic strategies is shown in figure 4.7.1.

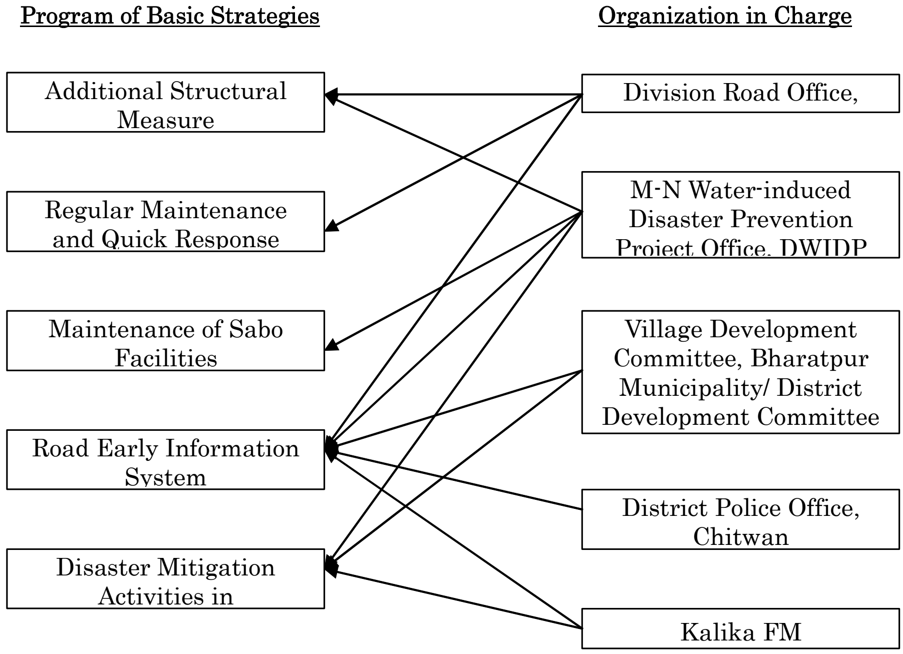


Figure 4.7.1 Implementation Organization for Basic Strategies

4.7.2 Necessary Expenditure

Necessary expenditure for the five basic strategies is 25,650,000 Rs. The structural measures for the expenditure cost 221,600,000 Rs.

4.8 Evaluation of Basic Strategies

4.8.1 Social & Environment

All items for the basic strategies (I: Additional structural measures, II: Regular maintenance and quick response, III: Maintenance of sabo facilities, IV: Road Early Information System, V: Disaster mitigation activities in communities) are not required in the initial environment examination (IEE) and environmental impact assessment (EIA) as per relevant environmental laws of the GON. Determining structural measures for the construction of sabo facilities is not the object of IEE and EIA. Natural preserved areas as well as significant archaeological and cultural areas require execution of EIA, however, the Study does not cover such areas.

Table 4.8.1 Deliberation and Points of Social/Environmental Consideration

Item	Content	Point of Consider
Accident/Disaster (risk)	Traffic accident under construction work	- Safety measure is required for inhabitants drivers, and workers under constriction work
	Inducement of slope disaster by construction work	- Prevent newly slope disaster by excavation work
Social, infrastructure Service	Road traffic obstacle by construction work	- Avoid road closure due to construction work
	Inaccurate early warning	- Appropriate criteria setting for early warning

4.8.2 Integrated Evaluation

Integrated evaluation of each basic strategy is shown in Table 4.8.2. The explanation of cost and benefit are described in previous section 4.2 to 4.5.

Benefit cost ratios of each basic strategy are higher than 1.0, indicating that it is economically feasible. This is more evident for basic strategy II (Regular maintenance and quick response) and IV (road early information system). Considerable annual benefits are obtained from strategy II, with 145 mil. Rs from regular maintenance and 53 mil. Rs from quick response. Annual benefit gained from strategy I (Additional structural measures) is also significant with 30 mil. Rs.

Table 4.8.2 Integrated Evaluation of Basic Strategies

Basic Strategies	Contents	Economical Evaluation	Remark
I Additional Structural Measure	9 sites measures to reduce potential annual loss under 1 mil. Rs/year of each sites	Total cost 204 mil. Rs Annual benefits 30 mil. Rs Benefit cost ratio = 2.0	Prominent risk sites (potential annual loss of more than 1 mil. Rs/year) will be reduced. Total potential risk will become 66% of the 2007 level. The project is feasible.
II Regular Maintenance and Quick Response	Routine maintenance, recurrent maintenance, rehabilitation works, rehabilitation works	2008/2009 FY requested expenditure 25 mil. Rs/year Annual benefit 145 mil. Rs/year Benefit cost ratio for maintenance = 5.2	Project is significantly feasible.
	Quick response	2008/2009 FY requested expenditure 53 mil. Rs/year Annual benefit 53 mil. Rs/year Benefit cost ratio = 33.6	Rationalization of the quick response will further enhance feasibility.
III Maintenance of Sabo Facilities	Deposit removal for 6 crossing streams where potential annual loss will be increase to over 1 mil. Rs in ten years.	Annual cost 1.0 mil. Rs/year Annual benefit 1.3 mil. Rs/year Benefit cost ratio =1.3	This is required for prominent risk sites (potential annual loss of more than 1 mil. Rs/year) consequent reducing potential loss. The program is feasible.
IV Road Early Information System	Road traffic	Annual cost 0.15 mil. Rs/year Annual benefit 10.56 mil. Rs/year Benefit cost ratio = 70	Project is significantly feasible.
V Disaster Mitigation Activities in Communities (Kabilash Village)	Early Warning/ Evacuation System for heavy rain	Annual cost 0.04 mil. Rs/year Annual benefit 0.71 mil. Rs/year Benefit cost ratio = 18	The purpose of the system is to avoid human lives losses. The rainfall monitoring in Kabilash Village can be efficiently utilized for the strategy IV

CHAPTER 5

PILOT PROJECT I：ROAD EARLY INFORMATION SYSTEM

5.1 Method of Pilot Project

The pilot project commenced after the work shop and joint exercise was conducted in 26th June 2008 and was completed on 20th November 2008.

Pilot project is carried out based on the process diagram shown in Figure 5.1.1.

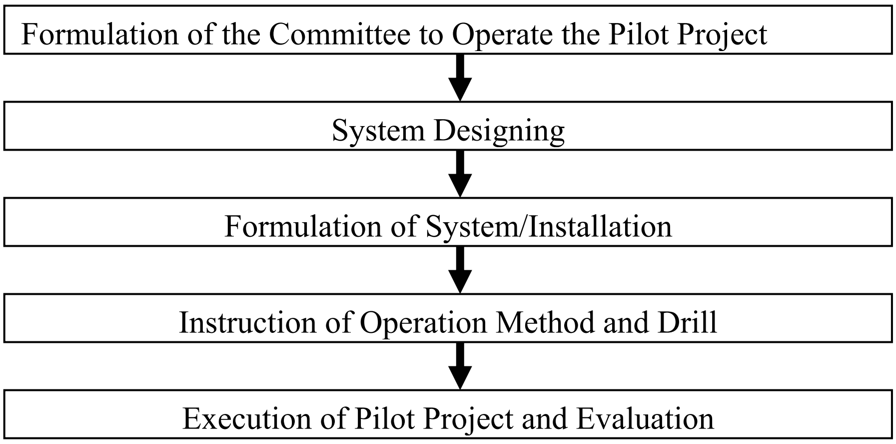


Figure 5.1.1 Process of Execution of Pilot Project

5.2 Organization of Pilot Project I

5.2.1 Forming of Committee

The committee for planning and managing the pilot project was formed. As pilot project I (Road Early Information System) and pilot project II (disaster mitigation activities in Kabilash Village described in Chapter 6) is closely related, the committee formed was named “Committees for the N-M Highway Early Information System and Water Induced Disaster Management for Kabilash Village”. Two committees were formed as shown in the Figure 5.2.1. The roles of members of the committee and implementing organizations are shown in the Table 5.2.1.

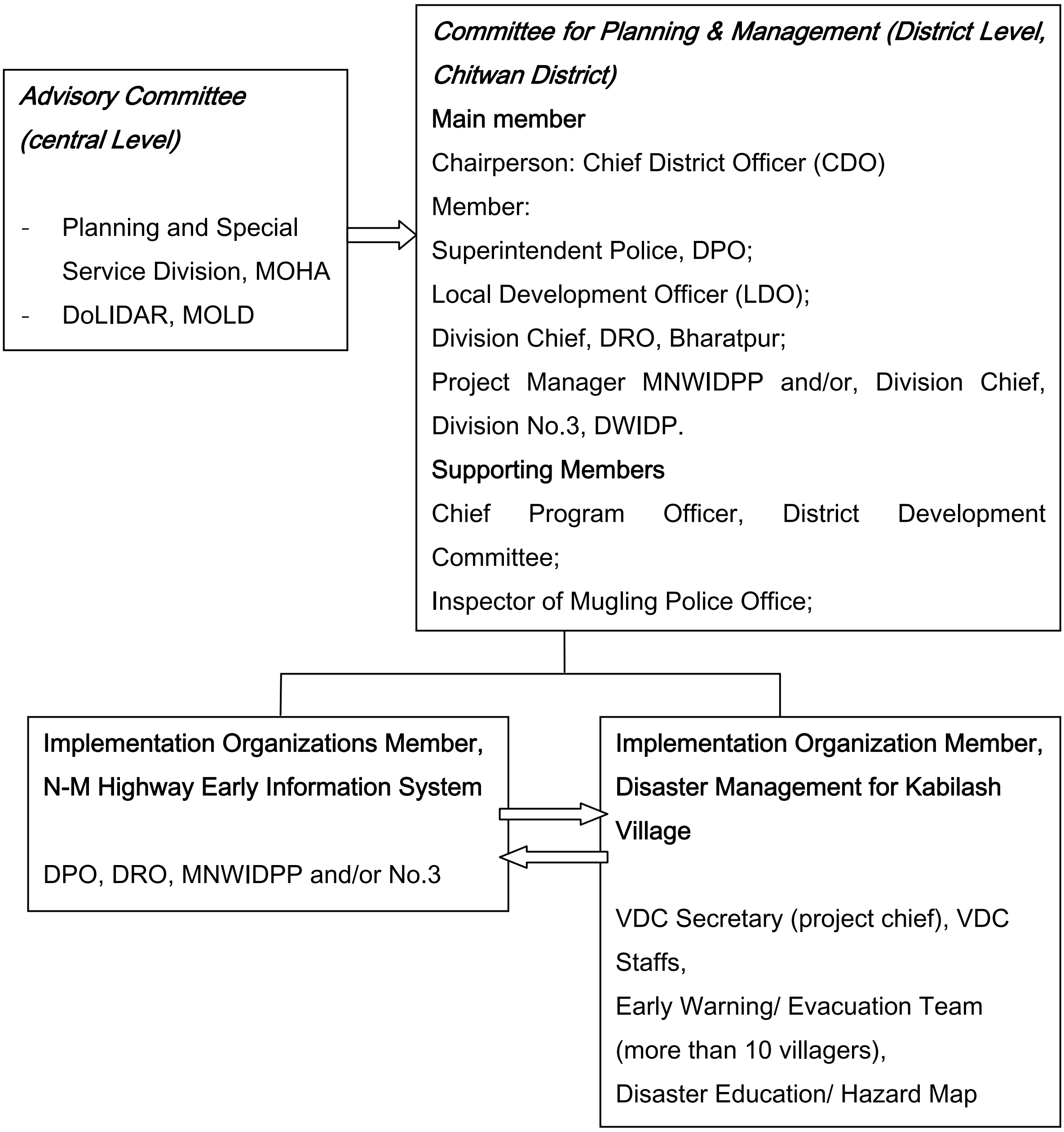


Figure 5.2.1 Committees and Implementation Organizations for the N-M Highway Early Information System and Water Induced Disaster Management for Kabilash Village

Table 5.2.1 Implementation Organization Members for Road Early Information System

Organization	Role
District Police Office (DPO) as Chief Organization	1. Operate and manage Road 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 has provided for uploading the N-M Highway early traffic 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.
Division Road office (DRO)	1. Monitoring of automatic raingauge at DRO office as follows. Once a day and or '12 hour rainfall exceeding 60 mm (responsible personnel notifies using buzzer alarm and/or through mobile phone)'; compute hourly rainfall data based on '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 the district police office is informed 2. Monitoring manual raingauge at DRO office at 11km, 21km and 31 km sections along the N-M Highway once a day for subservient data. 3. Report road traffic obstacles to police office/station by patroller, supervisors, and designated workers. 4. Urgent response to the road slope disaster. 5. Inspection and recording of road slope disaster. 6. Maintain following equipments which JICA has provided for rainfall monitoring, and data computation, & for uploading of '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 raingauge, three manual raingauges. 7. Pay CDMA phone communication fee for uploading web-page.
Kabilash VDC	1. Monitoring of automatic raingauge at Kabilash VDC (Chainage 10km of the N-M Highway) as follows. Once a day and or '12 hour rainfall exceeding 60 mm (responsible person notifies using buzzer alarm and or through mobile phone)'; compute hourly rainfall data based on '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 raingauge at Kabilash VDC (Chainage 10km of the N-M Highway) once a day for subservient data. 3. Explain about Road Early Information System to inhabitants. Facilitate inhabitants as monitor/reporter to police offices/station about road obstacle phenomena. 4. Maintain following equipments which JICA has provided for rainfall monitoring One computer with software, one USB, one CDMA phone, one automatic raingauge, one manual raingauge. (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 raingauges on Chainage 10 km of N-M highway. 2. Support Kabilash village technically and seek financial support to maintain following equipments which JICA is provided for rainfall monitoring one compute with software, one USB, one CDMA phone, one automatic raingauge, one manual raingauge.
Karika FM	1. Broadcast by radio the information of traffic obstacles/early warming under heavy rain
Hotels in Bharatpur,Mugling	1. Display information on traffic obstacles/early warning under heavy rain to hotel facilities users.

5.2.2 Sytem Designing

(1) Installation of Rain Gauge and Collection of Rainfall Data

To provide early information on dangerous rainfall intensity/pattern, automatic and manual raingauges are installed along N-M Highway as shown in the Figure 5.2.2.

Two automatic raingauges are installed at 0 km and 10 km considering the distances between location of computers and raingauges, and availability of maintenance. In addition to existing manual raingauge, four manual raingauges are installed at road sections 0 km, 10 km, 21 km and 31 km. The existing manual raingauge at section 11 km is is monitored and maintained by DRO.

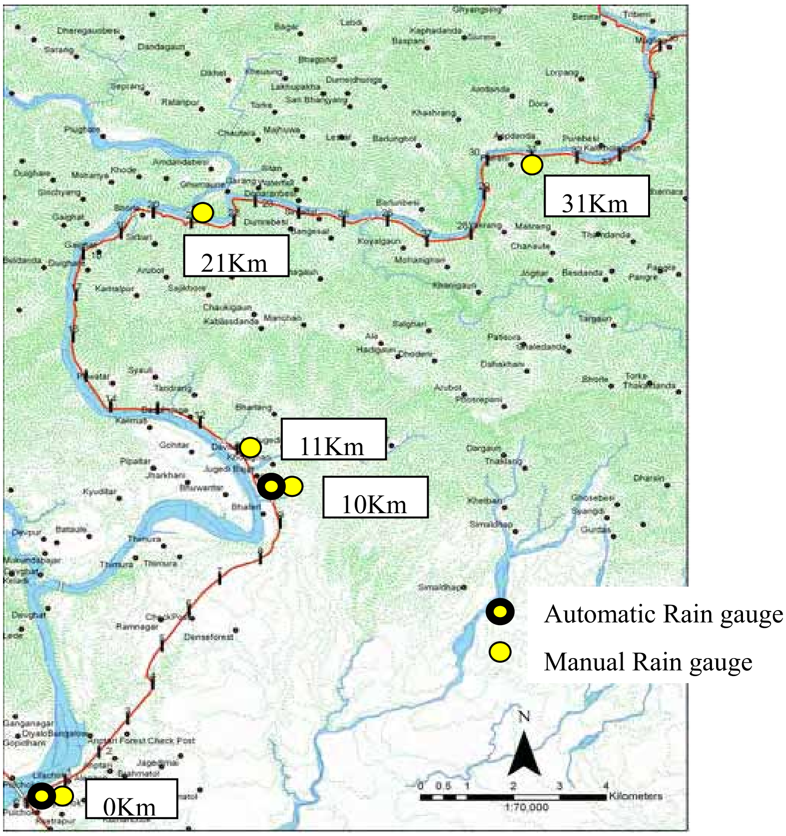


Figure 5.2.2 Location of Rain Gauge

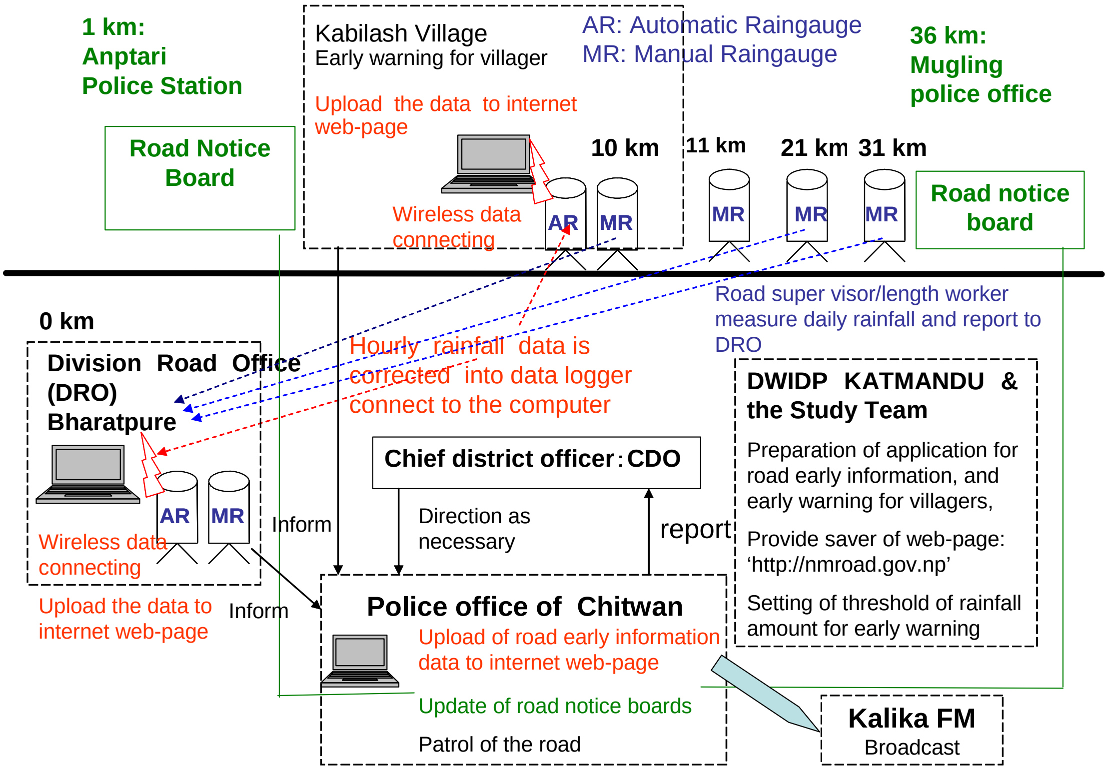


Figure 5.2.3 Schematic Chart of Road Early Information System

(2) Assessment of Rainfall Data

Assessment of rainfall data involves consideration of 12 hour half value rainfall amount. Threshold of critical level is set for four stages as shown in the Table 5.2.2. Determination of warning level is done by DRO who will report to the DPO for dissemination of warning to drivers.

Table 5.2.2 Threshold of Early Warning by Modified Rainfall Amount (Draft)

Early Warning Level	Threshold of rainfall	Recommendation
Level IV	12 hour half-value rainfall amount = 180mm Ten (10) year return period	Warning notice: Recommendation to avoid traffic on the road
Level III	12 hour half-value rainfall amount = 140mm Five (5) year return period	Caution notice: Recommendation to careful passage on the
Level II	12 hour half-value rainfall amount = 80mm Two (2) year return period	Same as Level I
Level I	12 hour half-value rainfall amount = 60mm One (1) year return period	Preparation Call up staff/workers/ equipment for emergency action by DRO

(3) Collection of Traffic Obstacle

Information on traffic obstacle collected by this system includes sediment-related disasters, traffic accidents and other occurrences which can not be collected automatically like rainfall data. Hence, reporting system performed by witnessing road administrator, drivers or passer-by is formulated.

(4) Content of Early Road Information by Notice Board

Items and contents of rainfall information and traffic obstacle information in the web page and notice board are shown in tables 5.2.3and 5.2.4

Table 5.2.3 Content of Warning Information

Item	Content of Web	Content of Notice Board
Warning Level	・heavy rain warning/ Recommendation to avoid traffic on the road ・heavy rain warning/ Recommendation to avoid traffic on the road/ Recommendation to careful passage on the road	Same as content of web
Section	From 10Km to 36Km point	Same as content of web
Date/time	Year/month/day/time	Same as content of web
Situation	・Rainfall intensity of 10 year return period ・Rainfall intensity of 5 year return period	—
Rainfall Graph	・12 hour half –value rainfall amount of 0km and 10km ・showing line rainfall graph of 7days	—

Table 5.2.4 Information on Traffic Obstacle

Item	Content of Web	Content of Notice Board
Traffic Condition	・Full lane traffic blockade ・Half lane blockade ・Traffic congestion	Same as content of web
Section	From defined distances	Same as content of web
Date/time	Year/month/day/time	Same as content of web
Reopening	reopening：Year/month/day/time	Same as content of web
Cause	・Flood ・Sediment-related disasters ・Traffic accident ・Unpredicted occurrences	Same as content of web

5.2.3 Installation of Devices

Required devices and instruments are installed based on system design:

- ◆ Automatic raingauge
- ◆ Manual raingauge

◆ Computer (CDMA, UPS)

5.2.4 Instruction on System Operation

Instruction on system operation for each operation unit and joint drill has been carried out as follows.

(1) Instruction on System Operation for

1) DPO
2) DRO Bharatpur, Chitwan
3) Kabilash VDC

(2) Joint Training Drill

Joint training drill on road early information system for N-M Highway and corresponding early warning/ evacuation system was carried out on 26th June 2008. (Refer to Data & Drawing)

One day drill along considering a scenario of disaster occurrence in the project area was carried out.

5.3 Implementation of Pilot Project I

5.3.1 Operation of Road Early Information System

(1) Operation Unit and Staff

This pilot project was carried out by DWIDP and DOR and concerned operation unit that were formulated in DPO, DRO, Kabilash VDC and Kalika FM.

(2) Operation of System

The rainfall monitoring by automatic/manual raingauges was carried out properly without difficulty. Monitored rainfall data were then uploaded to the web site

5.3.2 Traffic Closure Induced by Rock Mass Failure at 29km+850

Rainfall amount during execution of pilot project from July to September 2008 was so small that sediment related disaster occurred only once in 14th August 2008. The process and response for the disaster were as follows.

(1) Place of Rock Slope Disaster: N-M Highway km 29＋850

(2) Process of Slope Failure

A rock fall with a rock mass failure started to occur on 13th August 2008, at 12:00 p.m.. A road worker found the rock fall and reported to DRO, who ordered to prepare the heavy equipment while continuously monitoring the failure event. The rock mass failure ended on the 14th August 2008 at 0:00 a.m.

(3) Reopening Work

After slope failure ended, two loaders from DRO, Baharatpur commenced reopening works. Additional heavy equipment (excavator) from Hetauda was mobilized for the reopening works.

(4) Notification through Road Information System

Notification of road closure at 29 km was carried accordingly as follows.

- ✧ Display on Notice Board (road closure): 14th August 2008, AM 6:00
- ✧ Broadcast by Kalika FM: 14th August 2008, 7:00 AM
- ✧ Upload to the Web Site by DPO (road closure information): 14th August 2008, 8:00 AM
- ✧ Upload to the Web Site by DPO (reopening information): 15th August 2008, 4:00 PM
- ✧ Display on Notice Board (road Reopening): 14th August 2008, PM 6:00

Road early information system was utilized for notifying the traffic condition. However notice timing was not immediate enough, and should be improved for future events.

5.3.3 Weather Condition during Pilot project

Rainfall during execution of pilot project was very small compared with past records. Largest one day rainfall was 51mm/day in 12th July 2008. This was lower than rain fall data of past 10 years. Hence, rainfall intensity has not reached the warning level.

5.4 Evaluation of Pilot Project I

5.4.1 Summary of Evaluation

Summary of the evaluation is as follows.

Table 5.4.1 Summary of Evaluation for Pilot Project I: Road Early Information System

Narrative Summary	Objectively Verifiable Indicators	Verification Methods	Evaluation Result
Overall Goal			
Loss reduction of road users by selecting appropriate action (waiting, detour, cancellation) for road closure using timely information	➢ ASLp：Potential annual suspension loss of vehicles (Rs/year)	Questionnaire survey for road user after system installment and data analysis	**The system may provide 10% reduction of ASLp = 11 million Rs/year**
Improvement of traffic safety from road slope/water induced disaster	➢ Actual human lives loss and vehicles loss by road slope/water induced disaster	Disaster record (district police office)	**There were no human lives loss and vehicle loss during pilot project**
	➢ AHLLp: annual potential values of human lives lost (Rs/year)	Questionnaire survey for road user after system installment and data analysis	**The system may provide 50% reduction of AHLLp = 4,000 Rs/year**
	➢ AVLp: annual potential values of vehicles loss (Rs/year)		**The system may provide 50% reduction of AVLp = 8,000 Rs/year**
Project Purpose			
Usage of timely information on early warning and traffic obstacle	Recognition/action rate for the information of road user	Questionnaire survey for road user after system installment and data analysis	**Approximate 80% driver can understand, and take appropriate action**
Output			
Installation of workable system	Understanding level of participants of the system drill	Drill record	**Almost all staff can recognize the meaning of the system**
	Actual performance	Check by list in November 2008	**Related organizations performed smoothly except communication issue**
	Numbers of information provided	Operation record	**More than 15 times was uploaded during 4 months**
	Capacity of the organization related	Check by list in November 2008	**Concerned about lack of manpower in the future**

5.4.2 Evaluation of Project Output

(1) Hearing Investigation

Hearing investigations were initiated to measure objectively the verifiable indicators for road early information system and early warning/evacuation system for Kabilash Village. First evaluation was carried out to measure the understanding level of the operation staffs and the participants on the system during the joint drill in June 26th 2008. Second evaluation was carried out to consider the actual performance and the capacity of the concerned organization during execution of pilot project, in November 2008.

The result of first evaluation is summarized in Table 5.4.2 and Table 5.4.3.

Table 5.4.2 Result of Hearing for DOR, DPO and Kabilash VDC after Joint Drill

Hearing Item for Staff	Answer
1) Confirmation of Hourly Rainfall (4 Staff)	Easy 100 % Difficult 0 %
2) Operation of 12 hour half-value rainfall calculation program (4 Staff)	Easy 25 % Difficult 75 %
3) Uploading to Web page (4 Staff)	Easy 100 % Difficult 0 %
4) Request of warning for heavy rain (4 Staff)	Easy 100 % Difficult 0 %
5) Intercommunication on Kabilash VDC (13 Staff)	Easy 54 % Difficult 46 %

Table 5.4.3 Result of Hearing for Kabilash Villager after Joint Drill

Hearing Item for Participants of Practice (70 Participants)	Answer
1) Implementation of evacuation	Yes 100 % No 0 %
2) Confirmation of evacuation route	Easy 29 % Difficult 61 % Impossible 10 %
3) Confirmation of evacuation place	Easy 27 % Difficult 60 % Impossible 13 %

The result of second evaluation is summarized in Table 5.4.4 for Road Early Information System and Table 5.4.5 for Early Warning/ Evacuation System for Kabilash Village.

Table 5.4.4 (1) Evaluation for Road Early Information System during the Pilot Project (1)

Item	Organization	Good	Fair	Not good	Remark
1. Function of Equipment					
1-1. Automatic recording rain gauge	Division Road Office		V		0mm is recorded even under rainfall due to small reaf clog the funnel (2 times).
	Kabilash Village	V			
1-2. Manual (Non automatic) rain gauge	Division Road Office		V		Measuring cylinder for 11km has been broken.
	Kabilash Village	V			
1-3. Computer	District Police Office			V	It has been broken.
	Division Road Office	V			
	Kabilash Village	V			
1-4. CDMA pone	District Police Office	V			
	Division Road Office	V			
	Kabilash Village	V			
1-5. Notice Board for NMHEIS	District Police Office	V			
2. Operation of Equipment/System					
2-1. Calculation of modified rainfall amount	Division Road Office	V			
	Kabilash Village	V			
2-2. Upload of modified rainfall amount to web-page	Division Road Office	V			
	Kabilash Village	V			
2-3.Patrol/site confirmation for the serious disturbance/road closure	Division Road Office	V			
	District Police Office	V			
2-4. Upload road early information to web-page	District Police Office	V			
2-5. Posting road early information on notice board	District Police Office		V		Some staff does not recognize the procedure (Mugling police station)
2-6. Maintenance of the NMHEIS system	DWIDP		V		DWIDP provides the web-server. Initiative for the system are expected in the future
2-7. Data repository	DWIDP	V			
	District Police Office	V			
	Division Road Office	V			
	Kabilash Village	V			
2-8. Analyzed data from disaster management viewpoints such as modifying warning criteria	DWIDP	Not applicable			It should be conducted five year later
	Division Road Office		V		It should be conducted five year later DRO conducted comparison of manual rain gauges 11, 21, 31km and rain gauges of division road office
	District Police Office	Not applicable			It should be conducted five year later
3. Information Network					
3-1. Information to division police office when danger situation (modified rainfall amount is over the warning criteria, or serious disturbance/road closure is recognized)	Division Road Office		V		It is expected that more timely information
	Kabilash Village	V			
3-2. Information receive of heavy rain, serious disturbance, and road closure from related organizations and/or road user	Division Police Office	V			

Table 5.4.4 (2) Evaluation for Road Early Information System during the Pilot Project (2)

Item	Organization	Good	Fair	Not good	Remark
3-3. Information to Kalika FM (early warning and/or road closure)	Division Police Office		V		It would be better more timely information. Information should be road closure/traffic jam by accident.
3-4. Access to web-page of NMHEIS	Kalika FM		V		It is good after September.
	Hotels			V	It was not conducted so far.
	Transportation company			V	It was not conducted so far.
3-5. FM radio broadcast	Kalika FM	V			Informed by 'Traffic update' 9:15-9:20 AM Irregularly as emergency
3-7. Notice to hotel users	Hotels			V	It was not conducted so far.
3-8. Notice to drivers employed	Transportation company		V		8 in18 companies confirmed the board
4. Utilization by User					
4-1. Cognizance of notice board by driver	Road User		V		by interview on June and August
4-2. Visibility of letters of notice board to read by driver	Road User		V		by interview on June and August
4-3. Understanding for notice board by driver	Road User		V		by interview on June and August
4-4. Response for notice board by driver (to select appropriate action, or ignore the information)	Road User		V		by interview on June and August
4-5. Access to web page of N-M RIS	Road User		V		by interview on June and August

Table 5.4.5 Evaluation for Early Warning/ Evacuation System for Kabilash Village during the Pilot Project

Item	Organization	Good	Fair	Not good	Remark
1. Function of Equipment					
1-1. Automatic recording raingauge	Kabilash Village	V			
1-2. Manual (Non automatic) rainfall monitoring	Kabilash Village	V			
1-3. Computer	Kabilash Village	V			
1-4. CDMA phone	Kabilash Village	V			Some problems. After changing the phone, no probrem.
2. Operation of Equipment/System					
2-1. Calculation of modified rainfall amount	Kabilash Village	V			
2-2. Maintainance the WIDMSKV system	DWIDP		V		DWIDP provides the web-server. Initiative for the system are expected in the feature
	Kabilash Village		V		Rainfall calculation software has error. Need to be re-installed
2-3. Data repository	DWIDP	V			
	Kabilash Village	V			
2-4. Analyzed data from disaster management viewpoints such as modifying warning criteria	DWIDP	Not applicable			It should be conducted five year later
3. Information Network					
3-1. Information to Kalika FM (when modified rainfall amount is over the warning criteria of inhabitants)	Kabilash Village	V			So far, no opportunity. Drill was successed.
3-2. FM Radio broadcast	Kalika FM	V			So far, no opportunity. Drill was successed.
3-3. Information/Communication from rainfall monitor to Early Warning/Evacuation Team	Kabilash Village	V			So far, no opportunity. Drill was successed.
3-4. Information/Communication from Early warning/Evacuation Team to ward representative	Kabilash Village	V			So far, no opportunity. Drill was successed.
3-5. Information/Communication from ward representative to villagers	Kabilash Village	V			So far, no opportunity. Drill was successed.
4. Utilization by User					
4-1. Cognizance of WIDMSKV by villagers	Kabilash Villager	V			
4-2. Cognizance of early warning information by villagers	Kabilash Villager	V			
4-3. Evacuation action	Kabilash Villager	V			

(2) Information provision

The rainfall monitoring by automatic/manual raingauges was carried out properly without serious difficulty. Monitored rainfall data were then uploaded to the web site. Uploading by DPO was done only twice since traffic closure occurred only once, caused by a rock mass failure on 14th August 2008 at km 29+850. The website was accessed 1952 times as of the end of October.

5.4.3 Evaluation of Project Purpose

A traffic research for drivers passing the highway had been carried out with hearing investigation on NMHEIS in Anptari (46 drivers) and Mugling (180 drivers) in 26th June and 27th August 2008, where notice boards were installed. The result is summarized in Table 5.4.6 and Table 5.4.7.

Around 80% of drivers were able to understand the letters, notification and contents on the notice board during the hearing investigation. About 90 % of the drivers replied that they will wait until the indicated traffic warning on the notice board is lifted. Hence, it is considered that the road early information will be useful tool to mitigate traffic accidents induced by sediment related disasters and other traffic obstacles.

Table 5.4.6 Result of Research on Road Early Information System in June, 2008

Hearing Item	Mugling (46 drivers)	Anptari (180 drivers)
1) Understanding of Notice Information	Understood 50 % Did not understand 50 %	Understood 89 % Did not understand 11%
2) Response for Warning Notice	See and wait 72% Ignore 4% Hesitate 15% No answer 9%	See and wait 98 % Hesitate 2%

Table 5.4.7 Result of Research on Road Early Information System in August, 2008

Hearing Item	Mugling (46 drivers)	Anptari (180 drivers)
1) Understanding of Notice Information	Understood 78% Had difficulty understanding 17% Did not understand 4% No answer 1%	Understood 88% Had difficulty understanding 7% Did not understand 4% No answer 1%
2) Response for Warning Notice	See and wait 96% Ignore 4% Hesitate 1% No answer 1%	See and wait 95% Ignore 1% Hesitate 4%

5.4.4 Evaluation of Overall Goal

The overall goals of this project are to 1) Reduce losses of road users by selecting appropriate action selection (waiting, detour, cancellation) for road closure, using timely information and 2) Improve traffic safety against slope disaster/water induced disaster. The evaluation for overall goal is as follows.

(1) Loss reduction of road users by selecting appropriate action for road closure using timely information

➢ Actual loss of human lives as well as vehicles due to road slope/water induced disaster

There were no human lives and vehicles lost after the system installation. However, heavy rains that meet the warning criteria level did not occur during the rainy season of 2008 hence, no disasters occurred on N-M highway. Therefore the effect of the system it is not yet assured.

- ASLp: Annual Potential suspension loss (Rs/year)

Evaluation results of project purpose shows that approximately 80% of drivers recognize and understand the early road information, and more than 90% will take appropriate action based on the information. Therefore following scenario and improvement of objectively verifiable indicators are expected.

It is expected that 10% loss reduction of road users from current situation will be realized through the selection of appropriate actions (waiting, detour, cancellation) for road closure, based on timely information. Loss reduction is approximately 11 million Rs per year.

(2) Improvement of traffic safety from road slope/water induced disaster

- AHLLp: Annual potential values of human lives loss

Approximately 50% of AHLLp is saved and it is 4,000 Rs per year.

- AVLp: Annual potential values of vehicle loss

Approximately 50% of AVLp is saved and it is 8,000 Rs per year.

5.4.5 Evaluation of Organization

The organizations for the pilot project were evaluated based on both "2nd Committee Meeting of Chitwan District Disaster Management Partnership Committee for the Pilot Projects Early Road Information System and Disaster Management for Kabilash Village" and "Result of Pilot Project and Plan of Operation Next Year".

The result of the evaluation for each organization is summarized as in Table 5.4.8. Items for this evaluation are explained subsequently.

Table 5.4.8 Evaluation of Organization on Pilot Project

Organization	Item	Good	Fair	Not good	Remark
DPO (District Police Office)	1. Extent of efforts for pilot project in 2008	V			
	2. Budget for implemantation		V		Rs. 93000 in 2009.
	3. Capacity for implemantation		V		8 staffs. Computer operator is very limited. It is requred for manpower enfocement.
	4. Evaluation for future operation		V		
DRO (Division Road Office)	1. Extent of efforts for pilot project in 2008	V			
	2. Budget for implemantation	V			Rs. 117460 in 2009.
	3. Capacity for implemantation		V		7 staffs. They are too busy for ordinary road maintenance to operate the system
	4. Evaluation for future operation	V			
Kabilash VDC	1. Extent of efforts for pilot project in 2008	V			
	2. Budget for implemantation		V		Rs. 243590 in 2009. The budget plan should be revised more realistic one.
	3. Capacity for implemantation		V		3 staffs. Computer operator is very limited. It is requred for manpower enfocement.
	4. Evaluation for future operation		V		
Kalika FM	1. Extent of efforts for pilot project in 2008	V			
	2. Evaluation for future operation	V			Informed by "Traffic update"9:15-9:20 AM. Irregulary as emergency

The result in detail of the evaluation for each organization is described as follows.

(1) DPO

DPO was evaluated as "Fair". Although they basically have the ability to sustain the implementation of the system, personnel who possess capability in operating the computers are very limited. Therefore more personnel should be trained to operate the computers in the future.

(2) DRO

DRO was evaluated as "Good". They basically have enough ability and moderate budget for sustainable implementation of the system. However, personnel who are capable of operating the computers are not enough in the organization. The staffs seem too busy carrying out ordinary road maintenance works and have less time operating the system, especially during rainy season. Therefore more personnel should be trained to operate the system in the future.

(3) Kabilash VDC

Kabilash VDC was evaluated as "Fair". It proposes 243,590 Rs/year as budget for the implementation of the system in the future. However, it is difficult to secure the amount for their needs. The budget plan should be revised aiming for a more feasible amount. Persons who are capable of operate the computers are very limited in the organization. Therefore more persons should be trained to operate the computers in the future.

(4) Kalika FM

Kalika FM was evaluated as “Good”. It broadcasts “Traffic update" at 9:15-9:20 a.m. everyday. Information during emergency situation is broadcasted on a case to case basis. They have the ability and capacity to broadcast the road information both during regular and emergency situations in the future.

(5) Communication among organizations

According to the results of joint drill and hearing investigations, there were some problems with communication between organizations. It should be noted that smooth and timely communication is vital for the system operation. DRO and Kabilash VDC should obtain the information such as heavy rainfall and road obstacle as immediate as possible, while DPO provides Kalika FM without delay, information for uploading to the web page. The conceptual image on information flow for the system operation is shown in the following figure.

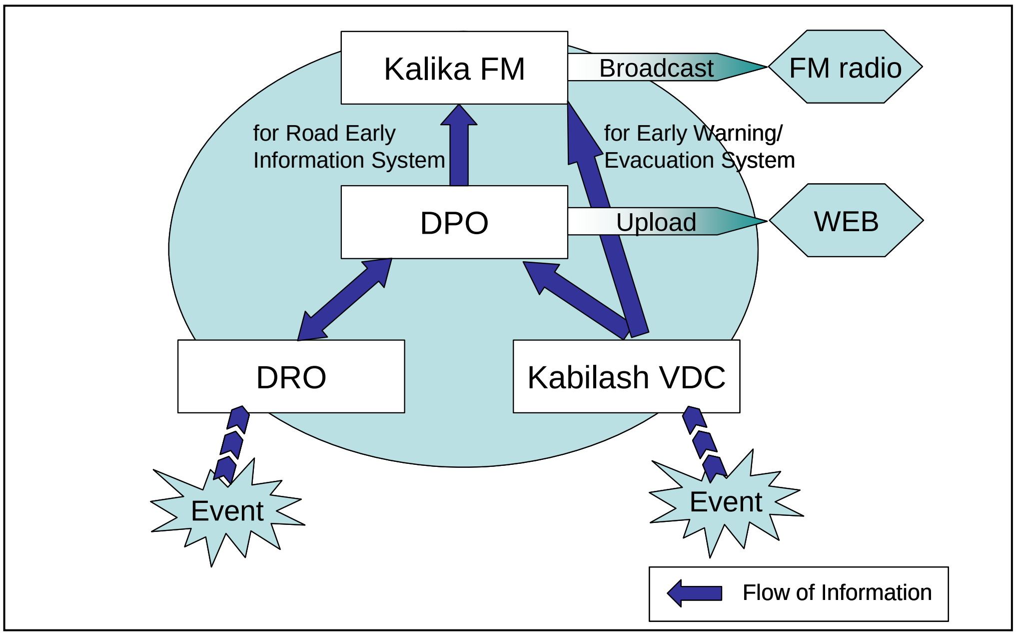


Figure5.4.1 Conceptual Image on Information Flow for the System Operation

CHAPTER 6

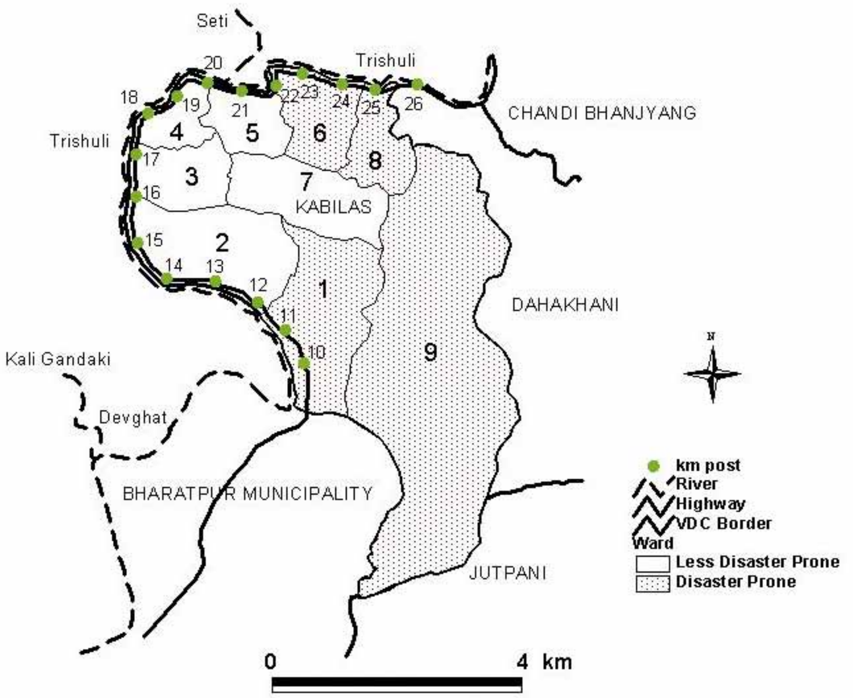
PIROT PROJECT II: DISASTER MITIGATION ACTIVITIES IN KABILASH VILLAGE

6.1 Objective and Target Area

Table 6.1.1 shows the objectives and the target area of water-induced disaster mitigation activities in Kabilash Village, which extends to the majority of the planned route extension.

Table 6.1.1 Objective and Target Area of Disaster Mitigation Activities in Kabilash Village

Item	Description
Objective	(1) Reduce water-induced disaster risk of inhabitants area, agricultural land, forest by villagers with appropriate activities (Some of the activities also affect the risk reduction of road slope disasters). (2) Avoid human lives lost by Early Warning/ Evacuation System using rain gauges.
Target Area	whole area of the operational district in Kabilash Village is divided into nine wards.



6.2 Project Items

This pilot project consists of five relevant units as follows:

1) Hazard mapping
2) Disaster education
3) Early Warning/ Evacuation System
4) Simple structural measures
5) Forestation planning and countermeasure planning

The disaster mitigation organization in Kabilash Village was formulated before the implementation of the pilot project. After the evaluation of the pilot project, the Team recommends and proposes continuous implementation and application of community-based disaster management to other communities. Table 6.2.1 shows work stages and inputs for the pilot project.

Table 6.2.1 Work Stage and Inputs for the Water-Induced Disaster Management in Kabilash Village

Item	Description
Item and work stage	**【First Stage】Mid-May to late-May 2008** - Formulation of disaster management organization which based on village development committee (VDC) in Kabilash Village. Recruitment of execution participant of simple slope protection works. **【Second stage】From early-June 2008** - Formulation of hazard map. - Preparation of educational materials for disaster management for inhabitants and students of the Kabilash school (regarding 'improvement of inappropriate land & water usage for water-induced disaster occurrence, introduction of effectiveness of simple slope protection works and vegetation for slope disaster prevention, relationship between slope disaster risk and rainfall, etc.). - Installation of raingauge in a village clinic and formulating of Early Warning/ Evacuation System. - Simple slope protection works including mulberry planting at crossing stream of chainage 11km+500m of N-M highway (restoration of surface soil erosion and reducing of incidence of slope failure by strengthening effect of mulberry roots, utilizing of mulberry leaves as feeding for livestock). - Planning of forestation which also affects to slope disaster prevention. **【Third stage】From late-June** (by disaster management organization) - Operation of Early Warning/ Evacuation System. - Maintenance of simple slope protection works and mulberry planting **【Forth stage】Mid-Nov to late-Nov 2008** - Evaluation of community based activities for disaster prevention - Recommendation/proposal for continuous implementation and spreading to the other communities of community-based disaster management
Inputs	- Raingauge, computer, CDMA phone - Text (Nepalese, using many drawing & figures) - Materials, hacks, and tools for simple structural countermeasure works - Mulberry nursery
Other	- Partnership with NPO Shaplaneer

6.3 Organization of Implementation

Disaster management activities are implemented by inhabitant's disaster management organization formulated under the village development committee (VDC) in Kabilash Village.

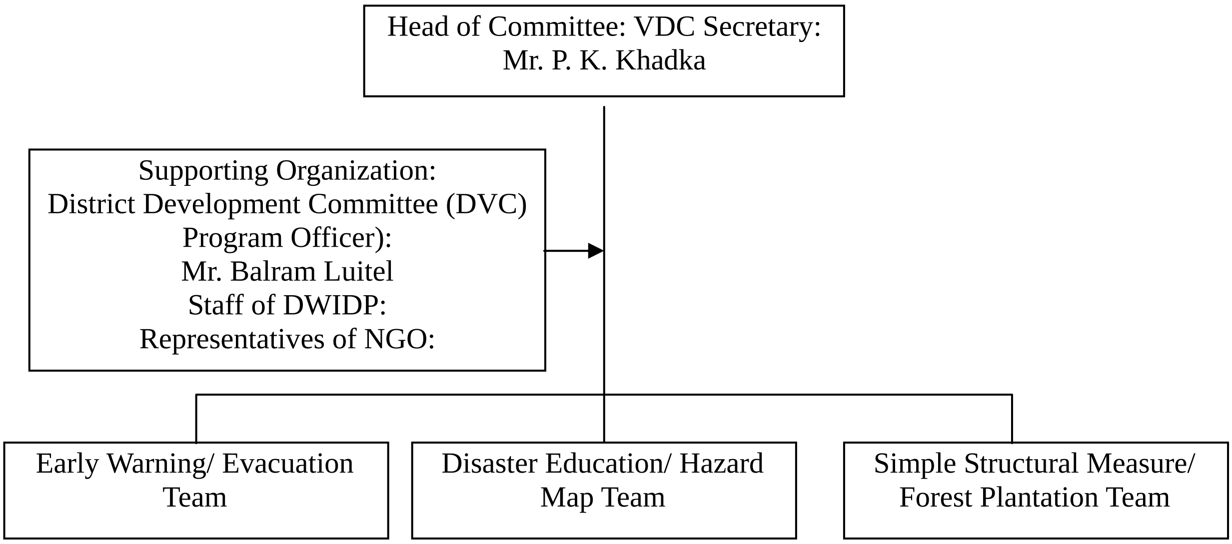


Figure 6.3.1 Disaster Mitigation Organization in Kabilash Village

VDC secretary will head the committee. The following three teams would be formulated by ward representative etc.

1) Early Warning/ Evacuation Team: The team administrates formulation and operation of the Early Warning/ Evacuation System. The team will be composed staffs from clinics, ward representatives, school teachers, etc.
2) Disaster Education/ Hazard Map Team: The team administrates hazard mapping and its revision (including the one intended for educational use), disaster education for school students and inhabitants in the village. The team will be composed of ward representatives, school teachers, etc. The team will also collaborate with NPO Shaplaneer.
3) Simple Structural Measures/ Forest Plantation Team: The team administrates simple slope protection works and planning for slope forestation in the village. The team will be composed of selected persons from wards and other volunteers. The team will also collaborate with NPO Shaplaneer.

6.4 Collaboration with Grassroots Activity

Water-induced disaster mitigation activities in Kabilash Village are implemented in collaboration with NPO Shaplaneer. Table 6.4.1 shows the policy proposed by the Team and a collaboration technique with grassroots activities for each relevant item.

Table 6.4.1 Collaboration Contents with Grassroots Activity

Items	JICA Study Team	Grassroots Activity	Collaboration Contents
Hazard Mapping	- Hazard mapping by satellite image (9 Wards). - Hazard mapping by topographical map (9 Wards).	Results: - Trainings for the risk assessment. - Hazard mapping. - Selection of countermeasure sites by the hazard maps. Follow-up: - Under consideration.	- Inspection of the hazard map by community, comparing the one by the Team. - Transfer of the technique to RRN. - Revision regularly of the hazard map (inspection before/ after rainy season).
Disaster Education	- Preparation of instruction materials. - Education to leader. - Education to students and villagers (7 schools/ 175 students, 9 Wards/ 429 villagers).	Results: - Speech competition at school in February and June. - Training at school by RRN staff. Follow-up: - Continuously execution of speech competition. - Utilization of the instruction materials by the Team.	- Education in Kabilash Village with instruction materials prepared by the Team. - Implementation of the education before rainy season every year. - Utilization of the leaders who were trained during the Study - Coordination by DWIDP.
Early Warning/ Evacuation System	- Formulating of Early Warning/ Evacuation Team. - Establishment of Early Warning/ Evacuation System. - Implementation of evacuation drill. - Operation of the system.	Results: - Formulation of committee for community disaster prevention. - Under preparation of action plans by the committee. Follow-up: - Formulation of information network on warning for the committee members.	- Collaboration between the disaster information system by the Team and the committee by grass roots. - Strengthening the transmission of information on the system. - Implementation of training drill. - Assistance for Chitwan District Disaster Management Preparedness Committee.
Simple Structural Measures	- Implementation of simple structure measure at CH 11km+500m on N-M highway. - Selection of structural measures points, and estimation of the cost.	Results: - 26 gabions were installed with hazard map by RRN staffs. Follow-up: - Under consideration.	- Inspection of the wickers - Technical evaluation of the gabions. - Operation of structural measure in the list prepared by the Team
Forestation Planning and Countermeasure Planning	- Formulation of forestation plan which is reforestation for places slash-and-burn by RRN and Simple Structural Measure/ Forest Plantation Team	Results: - Around 2000 trees were planted. - Establishment of community nursery Follow-up: - Continuously implementation - Under consideration for the diversity of the tree	- Implementation of the plantation on the site the Team selected. - Technical transfer trough the selection of the site.

6.5 Implementation of Pilot Project II

6.5.1 Hazard Mapping

The following two types of hazard map for nine wards was made based on collaboration between the Team and Disaster Education/ Hazard Map Team of Kabilash VDC, with cooperation from NPO Shaplaneer and NGO Rural Reconstruction Nepal (hereinafter described as RRN), which is conducting the "Disaster Preparedness and Sustainable Livelihood Development Project" in Kabilash Village.

A) Hazard maps based on satellite images

B) Hazard maps based on 1/25,000 topographic maps

Information on hazard maps was introduced along with the specifications in Table 6.5.1.

Table 6.5.1 Specification of the Hazard Map

Items	Description
Objective Ward	All wards of Kabilash Village
Description items of the hazard map	- Historical Disaster Situation: location, date/ time, causality, damaged situation, primary/ induced cause etc. - Hazard: potential disaster due to toe-cutting/ seepage/ streams/ roads/ fallen tree etc. - Risky buildings under heavy rains: dowelling houses, tool shed, animals shed etc. - Adverse affect slopes: inappropriate land use area (ex. slash-and-burn field, deforestation area), inappropriate water use (ex. great amount leakage irrigation), etc. - Expected forestation area: possible forestation area (ex. Community forest[1], Leased hold forest[2]). (Corroboration with NPO Shaplaneer) - Evacuation site/ route: Main evacuation route, evacuation site
Consideration	If one map with many descriptive items appears complicated, thematically separated maps would be made.
Updating of hazard map	Hazard map will be updated every few years depending on disaster occurrence or situation change. The Disaster Education/ Hazard Map Team should be in charge of the updating of the hazard map. The system formulation and education for hazard map updating would be conducted in the pilot project.

1 Community forest: Resident's common forest.
2 Leased hold forest: Forest where national forest has been loaned as resident's common forest for a certain period.

6.5.2 Education on Disasters

(1) Preparation of Education Materials

For education on disasters, the following materials (text book) were prepared:

A) Text book for leaders

B) Text book for students

C) Text book for villagers

In the text book for leaders, scientific knowledge and knowledge on actual disaster management are described in Table 6.5.2.

Table 6.5.2 Major Content of Education Material

Chapter: Title	Description Content
1: Introduction	General Method of Disaster Management/Importance of Disaster Management by Village/Purpose of Education on Disaster
2: Basic Knowledge for Water-induced Disaster	Topography and Geology of Kabilash Village and its Vicinity /Sediment-related Types of Disaster along N-M Highway and its Vicinity/Climate of Chitwan District/Rainfall and disaster in Chitwan district/Land, Water use in Nepal
3: Preventive Measures for Sediment-related Disasters in Kabilash Village	Simple preventive measures applicable for Kabilash Village
4: Hazard Map in Kabilash Village	Method of Hazard Mapping/Base Map/ Type of Dangerous Disasters in Kabilash Village
5: Early Warning and Evacuation	Warning Sign from Nature/ Early Warning and Evacuation System in Kabilash Village
Appendix	Hazard map of nine wards

Text book for students and villagers are re-edited based on the text book prepared for leaders. (Refer to Volume III Data and Drawing: Education Material and Volume V: Textbook of Education on Disasters)

(2) Implementation of Education on Disasters

Education on disasters was carried out for leaders of the village at first, in 27th August 2008. And, considering comments and requirements on disaster education material and methodology by leaders, education for students and villagers were planned and executed.

(a) Education on Disasters Intended for Leaders

Education on disasters intended for leaders was carried out in 27th August 2008 at the Meeting Hall of Kabilash village.

(b) Disaster Education for Students and Villagers

Considering comments and requirements of participants for leader's education mentioned above, text book for students and villagers were edited including related contents. Corresponding syllabus to be implemented was planned as shown in the table.

6.5.3 Early Warning/ Evacuation System

(1) Installation of Early Warning/ Evacuation System

Automatic recording raingauge and manual (non-automatic recording) raingauge were installed. Early Warning/ Evacuation System was formulated for actual operation. In addition, operation drill was carried out. Figure 6.5.1 shows the schematic diagram of the Early Warning/ Evacuation System.

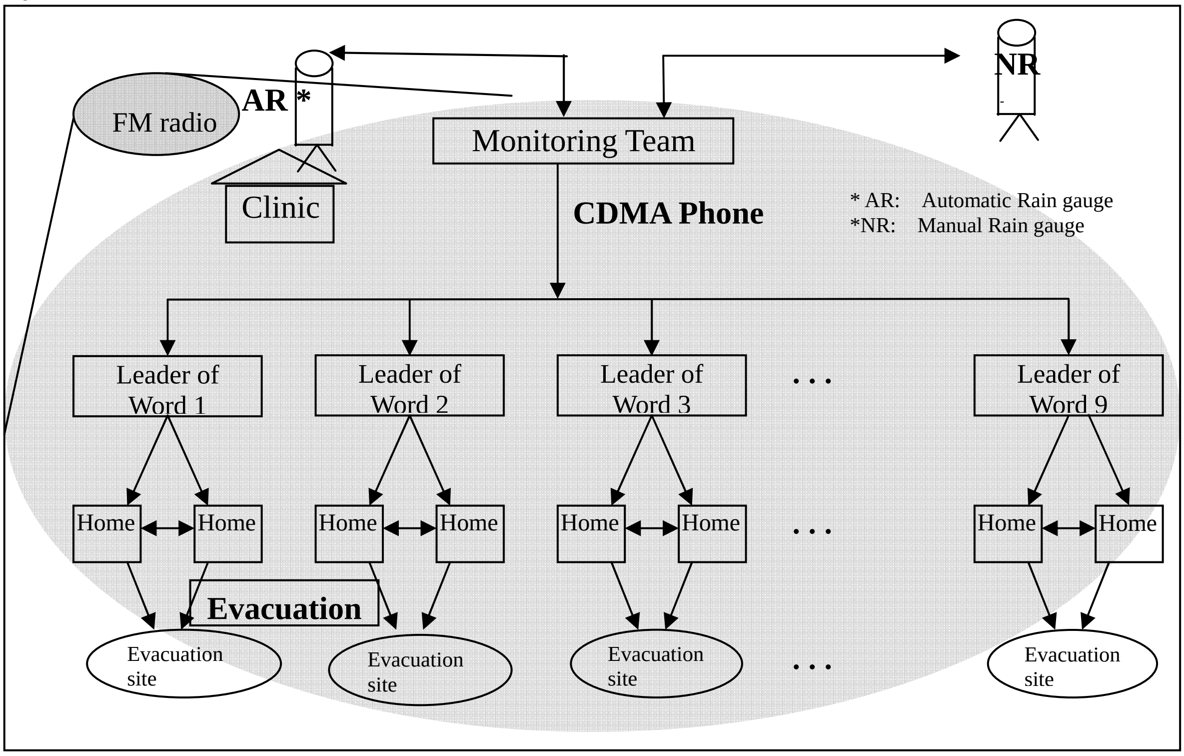


Figure 6.5.1 System of Information Transmission under Heavy Rainfall in Kabilash Village

The system is continuously operated until this project ends. The automatic recording rain gauge was set up in the health post in Kabilash Village, while the computer was set up in its VDC office. The Early Warning/ Evacuation Team of the resident disaster prevention organization was tasked to manage it.

Table 6.5.3 Threshold of Early Warning by Modified Rainfall Amount (Draft)

Warning level	Threshold of rainfall	Action
Level 1	12 hour half-value rainfall amount = 60mm (1 year return period)	Set into preparation - Announce to ward representatives - Check/ upload to web-page of modified rainfall amount every one hour
Level 2	12 hour half-value rainfall amount = 80mm (2 year return period)	Caution Notice - Recommendation of preparation for evacuation
Level 3	12 hour half-value rainfall amount = 140mm (5 year return period)	Warning Notice - Recommendation of evacuation

Table 6.5.4 Participants' Role on Early Warning / Evacuation System (Draft)

Participant	Role
(1) Kabilash VDC Secretary	✓ Declare recommendation of preparation for evacuation (at reaching Level2) and release ✓ Declare recommendation of evacuation (at reaching Level3) and release
(2) Kabilash VDC Assistant Secretary	✓ Act as VDC Secretary (when VDC Secretary cannot play his role)
(3) Kabilash VDC Early Warning / Evacuation Team	✓ Check rain gauge (everyday) ✓ Report to VDC Secretary about rainfall information
(4) Kabilash VDC Staffs	✓ Gather at the VDC office (at reaching Level1) ✓ Check rain gauge with Early Warning / Evacuation Team (after reaching Level1) ✓ Inform Caution Notice / Warning Notice to each Ward Representatives, PO and DRO
(5) Ward Representatives	✓ Inform Caution Notice / Warning Notice to villagers ✓ Grasp the situation of evacuation
(6) Villagers	✓ Inform Caution Notice / Warning Notice to neighborhood ✓ Evacuation

(2) Operation of Early Warning/ Evacuation System

Pilot project on the early warning/ evacuation system commenced after a joint drill conducted on 26th June, and was completed on 20th November 2008.

(3) Weather Condition During Pilot Project Execution

The rainfall during the execution of pilot project was minimal as compared to previous records. Due to this weather condition, rainfall intensity has not reached the warning level.

6.5.4 Simple Structural Measures

It is preferable that villagers themselves carry out simple slope protection works including its maintenance. Therefore, Simple Structural Measure/ Forest Plantation Team should be designated for its construction in order to acquire working plan/ technology and the management method for the countermeasures. Considering this, it is realized that it is possible to perform easy repairs when maintenance is properly conducted.

Figure 6.5.2 shows the construction situation of a simple countermeasure work at the crossing stream of N-M Highway Chainage km 11+500m. Table 6.5.5 meanwhile shows the required procurement materials for the pilot projects.

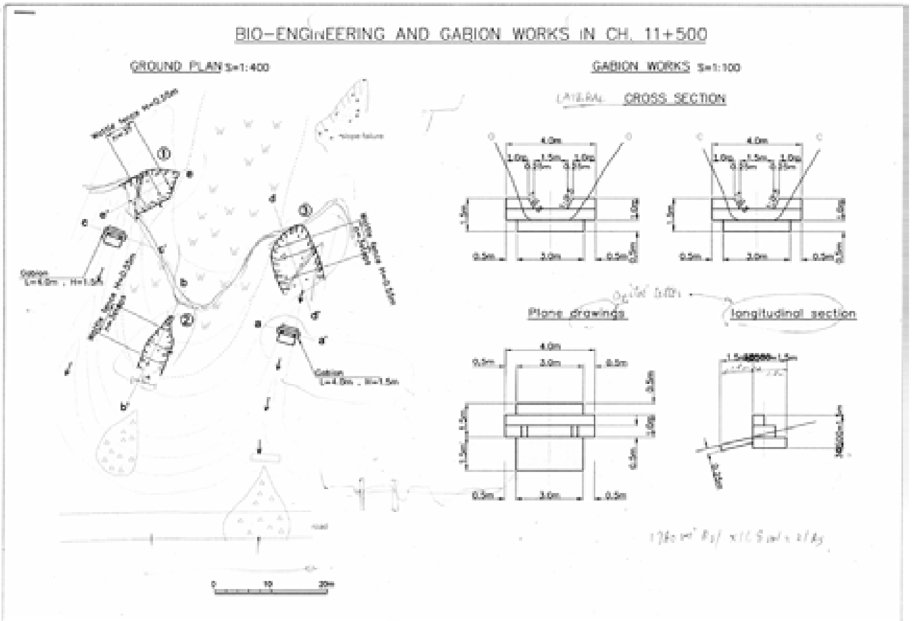


Figure 6.5.2 Simple Slope Protection Works at Crossing Stream of N-M Highway Chainage 11km+500m

Table 6.5.5 Required Procurement Materials for the Pilot Projects (These are included in te contract with RNGO)

Item	Description	Unit	Quantity
Shovel		nos.	10
Pickax		nos.	10
Big wooden hammer		nos.	10
Small wooden hammer		nos.	10
Gabion material	for selvaged zinc coated gabion boxes	m^2	100
Rounded wood	1.2 m length, φ 0.11 m	nos.	260
Rounded wood pile	2.0 m length, φ 0.11 m	nos.	350
Mulberry sapling		nos.	610

6.5.5 Forestation Planning and Countermeasure Planning

Forestation and simple countermeasure planning was carried out in the pilot project. But, the Study Team did not take part directly in the forestation planning. This work was carried out by cooperation of the Simple Structural Measure/ Forest Plantation Team of disaster mitigation organization in Kabilash and NGO RRN. The Team advises the joint team composed of Simple

Structural Measure/ Forest Plantation Team and NGO RRN.

(1) Forestation Plan

NGO RRN and Simple Structural Measure/ Forest Plantation Team made up the following forestation plan which involves reforestation for slash-and-burn places.

- Area of reforestation: Around 25,600 tree planting planned for 55 sites in 8 wards of 27 ha for slash-and-burn places.
- In addition to reforestation, the following programs are also being studied.
  A) Alternative Wood Fuel Provision Program; briquettes provision and improved stove provision.
  B) Reduction of local alcohol production
  C) Control timber fire wood selling

The Team assisted only in the preparation of tables for planning and identifying locations in hazard maps. Implementation of above plan is being studied by both NGO RRN and Simple Structural Measure/ Forest Plantation Team.

(2) Simple Countermeasure Plan

Eleven sites are selected for implementing the simple countermeasure considering requirement of the village people. Total cost of countermeasure is around 4 million Rs. The Team assists and advises on plans of countermeasures for each site.

Countermeasure work for each site can be implemented through the skills of the village people. However, more practical plan shall be elaborated considering prioritization of sites and village's availability of budget.

6.6 Summary of the Evaluation

6.6.1 Summary of the Evaluation

Summary of the evaluation is as follows.

Table 6.6.1 Summary of Evaluation for Pilot Project II: Disaster Mitigation Activities in Kabilash Village

Narrative Summary	Objectively Verifiable Indicators	Verification Methods	Evaluation Result
Overall Goal			
Reduction of resident's water induced disaster risk	ANHLLp : Potential annual number value of human lives loss (persons/year)	Interview survey for villager after installation of the Early Warning/ Evacuation System and data analysis is performed	**The system may provide 50% reduction of ANHLLp = 2.1-1.1 persons/year**
	Note: Evaluation is for Early Warning/ Evacuation System only. Because other items of pilot project II is difficult to evaluate so far.		
Project Purpose			
Improvement of slope stability level by simple structural measure	Situation of the simple structural measure site (crossing stream of km 11 +500 of N-M Highway)	Check after installation of simple structural measures	**Slope stability work on the site was successfully conducted**
Improvement of knowledge for disaster management activities	Reorganization level of the Early Warning/ Evacuation System	Record of early warning/evacuation drill	**Project activity has greatly sensitized the community people about disaster**
	Residents' understanding level of disaster education material	Record of hazard map creation/disaster education	
Strengthening of disaster risk management	Residents' understanding level for overall disaster risk management	Consideration of evaluation for the output	**Disaster risk management has been strengthened with some activities**
Output			
Hazard map	Number of participants, Understanding level of participants	Record of hazard map creation	**One-third of around 20 participants understood what is hazard map**
Material and activities related to disaster education	Number of participants, Understanding level of participants	Record of disaster education	**Half of around 600 participants understood the educational contents**
Early Warning/ Evacuation System	Understanding level of participants on the system drill	Record of warning/evacuation drill	**Almost all staffs understood the meaning of the system**
Simple structural measures	Situation of the simple structural measure site.	Site inspection, Photograph	**Slope stability work on the site was successfully conducted**

6.6.2 Evaluation of Project Output

Project output is classified into 1) Simple slope stability structure, 2) Hazard map, 3) Disaster education material and education activities, and 4) Early Warning/ Evacuation System. The evaluation is conducted for each output.

(1) Hazard map

Method:

Hazard map is evaluated by the participants. Understanding level of participants for the creation of the hazard map was determined. The understanding level is judged by the lecturer since the related questionnaires have not been done for the participants.

Evaluation:

When the Team collected information for preparation of hazard maps, more than 20 villagers including a representative from ward, staff and normal villager participated in the meeting.

During this period, the Team explained to the villagers the significance and the preparation method of hazard map in order to obtain sufficient information. After explanation was carried out, one-third (approximately 33%) of the villagers were able to provide appropriate information to the Team related to making the hazard map. This means that said one-third of the participants understand the meaning of hazard map. The method of detailed preparation of hazard map would be explained to villagers that have education on disasters, as disucussed below.

(2) Material and activities related to disaster education

Method:

Education on disaster is evaluated by the participants while their understanding level is determined. The understanding level is judged by the lecturer since the corresponding questionnaires required for investigation have not been done.

Evaluation:

The session for the education on disasters for leaders include 44 participants composed of school teachers, ward representatives, VDC staffs and engineers. Meanwhile, the session for the education on disasters include a total of 7 schools, 175 students and 429 villagers from all wards.

During the lecture, there was a question-and-answer portion wherein the lecturer asked the participants about disaster-related activities including hazard mapping, to confirm their understanding level. It was judged that around half of the participants were able to answer the questions.

(3) Early Warning/ Evacuation System

Method:

The understanding level of participants on the early warning/ evacuation system is evaluated after carrying out a drill. The understanding level of participants in Kabilash Village is judged based on questionnaires handed after the conducted drill discussed in chapter "5.4.2 Evaluation of Project Output".

Evaluation:

Thirteen operation staffs, composed of secretary and representative from ward, and 70 or more villagers participated in the drill for the early warning/ evacuation system on June 2008.

Almost all the operation staffs understood the meaning of the system and its operation method. Although some villagers found difficulty in identifying the evacuation route and/or places by themselves, they managed to evacuate during the drill. The detail is described in chapter "5.4.2 Evaluation of Project Output".

(4) Simple structural measures

Method:

Simple slope countermeasure is evaluated through site inspection and photographed observation of the situation after construction.

Evaluation:

The countermeasure was conducted at crossing stream of N-M Highway Chainage km 11+500 on middle of June 2008. The Team has checked the structure at the site on late August and late November, 2008. Judging from the observation, the countermeasure is stable on the slope. The simple countermeasure work was successfully completed and contributed to the stability of the slopes. Stabilization was also attributed to some vegetation at site.

6.6.3 Evaluation of Project Purpose

Project purposes, which are classified into 1) Improvement of slope stability level by simple structural measure, 2) Enhancement of knowledge for disaster management activities and 3) Strengthening of disaster risk management, are evaluated based on the evaluation of project output.

(1) Improvement of slope stability level by simple structural measure

The simple countermeasure work at chainage km 11 km+500 was successfully completed and contributed to the stability of the slopes as previously mentioned. Further simple countermeasure work for slope stability was proposed as part of continuous implementation and dissemination to other communities.

This means that the slope stability level in the area has been improved by simple structural measures introuduced trough this project.

(2) Enhancement of knowledge for disaster management activities

Judging form the results of record on hazard map creation/ disaster education/ early warning and evacuation drill, the project has been able to achieve the target for enhancing knowledge for disaster management activities in the community. At the same time, it has sensitized the community to a great extent realizing their curiosity on water induced disasters during consultations with the project staff and other staff working in the GON. In this sense, the first goal of the project has been well accomplished which has opened straightforward scope for further works in the site. This is not merely realized by asking with the concerned stakeholders but also from the response of the concerned GON employees.

In general, the project activity has greatly sensitized the community on water induced disaster management. However, there are still more work to be done with regards to education on disaster. This aspect needs to be well covered in future programs.

(3) Strengthening of disaster risk management

The ability of the disaster risk management in Kabilash Village is judged based on the evaluation of the project outputs. The disaster risk management has been strengthened with the activities in this project during the implementation of the following.

- Consideration of the simple countermeasure for slope stability
- Preparation of hazard map and data collection for it
- Comprehensive disaster education
- Establishment of Early Warning/ Evacuation System
- Adequate evacuation by villagers themselves
- Effective forestation planning and countermeasure planning

As mentioned in previous session, these activities have greatly improved the community, their organizations and the related system in the village with regards to disaster risk management.

6.6.4 Evaluation of Overall Goal

(1) Overall goals and evaluation method

Evaluation of overall goals is conducted for early warning/ evacuation system only since it was still difficult to evaluate other items of the pilot project II. But hazard mapping, education on disasters and simple structural measures can already contribute to saving human lives.

Overall goals are evaluated by considering the outputs and achievement of the project purpose.

(2) Objectively verifiable indicators and evaluation results

Objectively verifiable indicator is AHLLp which relates to annual potential value of human lives loss (Rs/year).

The early warning/ evacuation system may save 50% of current AHLLp = 70,000 Rs/year. The saved percentage will further increase by continuously achieving efficient hazard mapping and disaster.

Current AHLLp is estimation by manipulation of ‘current annual potential numbers of human lives loss’ and unit value of human lives loss (UHL).

Current annual potential number of human lives lost is estimated to be 2.1 persons per year, based on 21 persons who died in the past ten years. Consequently, UHL is 674,000 Rs/person, which is determined based on ‘the number of years/days of work lost due to death, and ‘the average annual income of the person who died’.

This indicator is just based from income of the person, without considering the mentality lost of the lost persons.

CHAPTER 7

STRUCTURAL COUNTERMEASURES FOR RUWA KHOLA/MARSYANGDI HYDROPOWER PLANT

7.1 Concept and Design

7.1.1 Concept of Design

(1) Basic Concept

(a) The object to be protected is the Marsyangdi Hydropower Plant.

(b) The size or scale of the additional countermeasures is determined considering that the additional countermeasures cope with the 2003 heavy rainfall.

(c) No modification with the existing appurtenant facilities for the power plant such as its intake and access.

(d) No modification with the existing sabo dams. Hence, the existing facilities are used to maximize the capacity by improving their functions.

(e) The additional countermeasures were proposed on the downstream area because of difficulty in accessing the upstream area.

(2) Selection of Additional Countermeasures

Figure 7.1.1 conceptually shows the effectiveness of debris flow guide concrete wall.

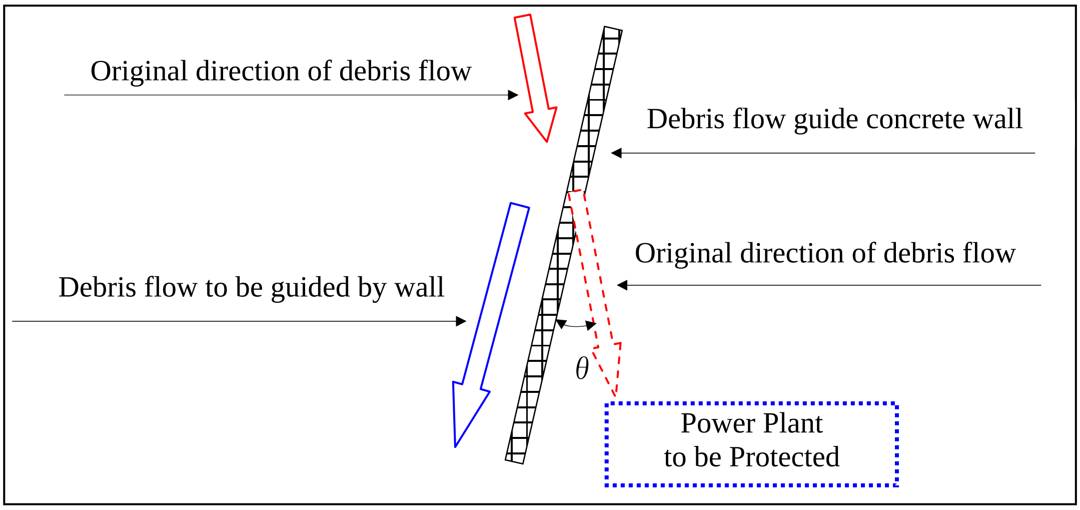


Figure 7.1.1 Effectiveness of Debris Flow Guide Concrete Wall

7.1.2 Design of Structural Countermeasures

The standard section of debris flow guide concrete wall is showed in Figure 7.1.2.

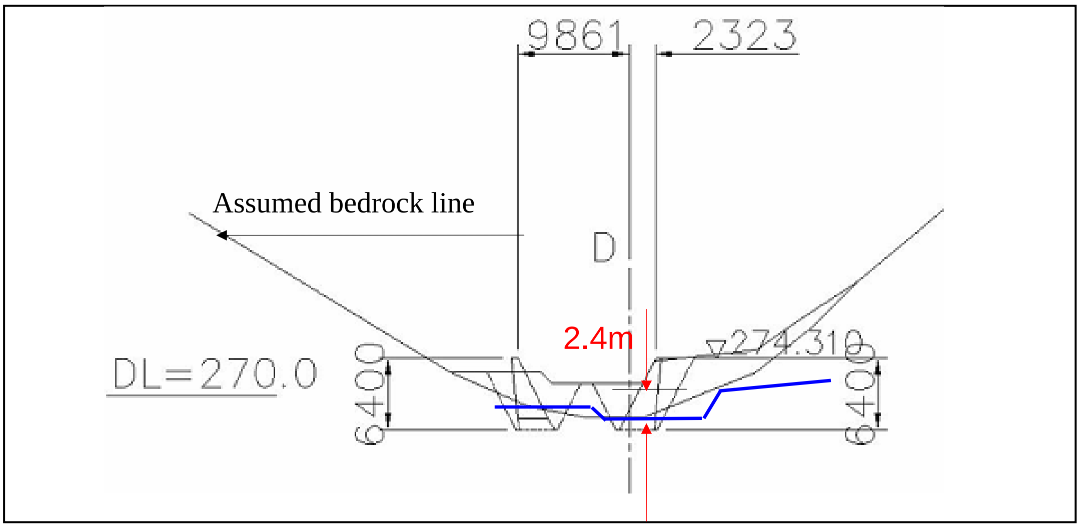


Figure 7.1.2 Standard Section of Debris Flow Guide Concrete Wall

Total quantity of the related works at site is summarized in the table below.

Table 7.1.1 Total Quantity of the Work

Work	Description	Quantity
Excavation of common	Soil + Soft rock	7,747.0 m^3
Backfill		5,554.0 m^3
Concrete		2,606.4 m^3
Form work	Wooden	3,204.9 m^2

7.1.3 Construction Plan

(1) Organization for Implementation

The Marsyangdi Hydropower Plant has been managed by Nepal Electric Authority (NEA). However, according to discussions with counterpart organizations and related agencies, it is finally proposed that the DWIDP will take all responsibilities as the implementing agency for the proposed works.

(2) Construction Procedure for Concrete Wall

The construction procedure is shown in Figure 7.1.3. During the foundation excavation and concrete placing, river flow must be guided by the excavated lines. Because the width of the river and discharge are large, and the existing concrete sabo dams will be an obstruction in excavating a deeper diversion channel for the present riverbed, piling of soil bags is recommended to form a diversion channel.

1) Preparatory work
↓
2) Diversion channel
↓
3) Excavation and spoil bank
↓
4) Foundation treatment
↓
5) Framework and scaffolding
↓
6) Concrete placing
↓
7) Filling up

Figure 7.1.3 Construction of Guide Concrete Wall

(3) Construction Schedule

The following figure shows the construction schedule for guide concrete wall works.

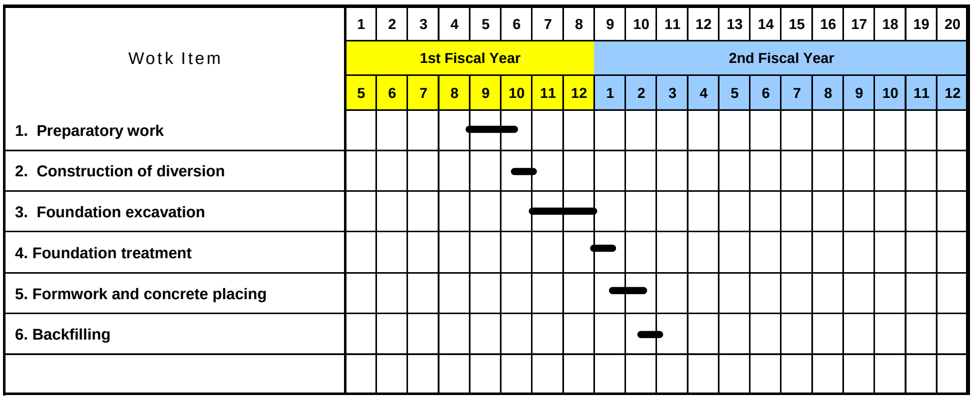


Figure 7.1.4 Construction Schedule for Guide Concrete Wall

Rainfall and flood will largely influence construction time, quality and safety. It is thus proposed that foundation excavation commence after the rainy season and backfill to be completed before subsequent rainy season.

7.1.4 Project Cost Estimation and Cost-Benefit Analysis

(1) Total Cost Estimation

The work quantities for the designed revetment-type guide concrete wall were calculated on the basis of the layout of the structures. The construction cost was estimated to be 18,363,663. Rs, which include 13% VAT.

(2) Cost-Benefit Analysis

The method of cost-benefit analysis is discussed in detail in Chapter 4. The result of said analysis for the structural measures at the Marsyasngdi Power Plant site is summarized in the following table.

Table 7.1.2 Results of Cost Benefit Analysis

ALp (mil.Rs/Year)	Construction Cost (mil.Rs)	RRR (Risk Reduction Ratio)	BCR	ENPV (mil.Rs)
4.858	18.364	0.90	1.99	12.759

7.2 Project Evaluation

7.2.1 Social and Environment

(1) Social Evaluation

After construction of guide walls, the function of the facilities of Marsyangdi Hydropower Plant and the highway bridge will be possibly protected from debris flow.

- Marsyangdi Hydropower Plant

  By implementing the guide concrete walls, it will be possible to control debris flows similar to the 2003 disaster level. Moreover functions of the power plant will be kept safe.

- Highway bridge and securing the traffic

  As the guide concrete walls can smoothly flow out the flood of the debris flow to the main stream, bridge will be safe from influence of scouring and over topping.

(2) Environment Evaluation

The guide walls are not constructed in the river bed but implemented along both banks of the valley. Thus, impact for natural condition will be very low and river bed will be stabilized by the smooth river/debris flow.

7.2.2 Comprehensive Evaluation

This project is feasible and can be implemented with minimum impacts. Consequently, after completion it will generate favorable effect to the social and natural environment.

CHAPTER 8

TECHNICAL TRANSFER

8.1 Technical Advice on Structural Measures

8.1.1 Background

After the 2003 water-induced disasters in the NM Highway, various countermeasures were implemented in 2004 and 2006. However, as visibly observed along the highway, some implemented structures were damaged either partially or completely. It is considered that these damaged structures must have some engineering deficiencies in terms of planning/designing/ construction which should be improved in the future. Therefore, a technical reference related to the design and construction of the structural measures, especially focusing on those damaged structures, is deemed necessary. In the aspect of technical transfer, a technical reference document entitled “Technical Guide on Sabo and Road Slope Protection Works” was prepared as a separate volume of this Study.

8.1.2 Purposes

This technical guide is intended to provide some technical reference or guidelines for DWIDP and DOR engineers. Its main objective is to assist DWIDP and DOR engineers or also other technical staff that are concerned on planning, design, construction and supervision of road slope disaster mitigation measures.

8.1.3 Outline of Technical Guide

The guide provides technical guidance on the design and construction of structural measures. It comprises three parts.

Part I contains Sabo Work, which mainly deals with mitigation of debris flow disasters.

Part II contains Road Slope work, which mainly discusses the requirements of structural measures related to road slope disasters.

Part III contains Maintenance Work, which briefly describes the maintenance practices.

This guide will be finalized considering the discussion, comments and requirement mentioned above. This is a very preliminary technical material and hopefully can be updated by DWIDP and DOR technical staff with enhancement of future engineering practices.

8.2 Technical Transfer on Disaster Information System and Disaster Education

8.2.1 Disaster Information System

Technical transfer on disaster information systems (Road Early Information System and Early Warning/ Evacuation System) for staffs of Bharatpur Road Office, Chitwan Police Office and Kabilash VDC had been carried out during the following seminar/workshop with operation training, which is described in Chapter 5.

- 18th June for DRO and DPO
- 19th June for Kabilash VDC
- 26th June Joint Seminar/ Workshop with Operation Training

Through these instructions of technical transfer on the disaster information system, staffs in charge of the system have obtained related operational skills.

8.2.2 Education on Disasters

As described in Section 6.5, the technical transfer for the education on disaster is composed of the following three points.

(1) Educational materials for the education on disasters

(2) Implementation of the education on disasters for the community

(3) Formulation and implementation of Early Warning/ Evacuation System

(1) Educational materials for disaster education

The educational materials for the residents and the students in the village are as follows. The education using these materials is based on community-based disaster preparedness. Leaflet for the education written in Nepalese is handed down to all residents of the village.

(2) Implementation of the education on disasters for the community

The Team conducted training to the Disaster Education/ Hazard Map Team in VDC organization at the end of August 2008. The Disaster Education/ Hazard Map Team obtained sustainable programs related to education on disasters during this training.

(3) Formulation and implementation of Early Warning/ Evacuation System

The Team conducted training to the Early Warning/ Evacuation Team and Disaster Education/ Hazard Map Team formulated in VDC organization.

CHAPTER 9

CONCLUSION AND RECOMMENDATION

9.1 Conclusion

9.1.1 Risk Level of Narayangharh-Mugling Highway

Risk evaluation has been carried out from view points of geo-topographical and economic loss induced by sediment related disasters.

(1) Hazard Condition from View Points of Topo-Geological Aspect

Hazard condition of the target area was assessed by interpreting the aerial photo, satellite image and field geological survey including boring and electric investigation.

a) It is suspected by interpreting aerial photo and satellite images that around 30 slopes were deformed by landslides or rock creep. However, it was found during the geological survey that these are not currently active as catastrophic landslides
b) Lower parts of the slopes facing the road are prone to collapse under heavy rain,
c) Landslides and slope collapses are occurring in tributary valleys crossing the highway which are potential source of debris flow.

(2) Risk Assessment by Economic Loss of Slope Disasters

The risk before 2003 disasters and current total risk has been estimated to be 194 ALp (mil Rs) and 106 ALp (million Rs) respectively.

Drastic improvement of risk level of current situation from 2003 has been generated by the rehabilitation work named Road Maintenance and Development Project, Road Rehabilitation Component for N-M Highway, which had been done from 2004 to 2006 by DOR, and preventive work named Mugling-Narayangharh Water Induced Prevention Project (MNWIDPP) which is being implemented from 2004 by DWIDP.

The effectiveness of above mentioned countermeasures are realized in 2006 when no serious road blockade happened during heavy rain falls in which was of same magnitude as the 2003 rainfall that induced considerable disaster.

9.1.2 Basic Strategy Disaster Risk Management

Considering current risk level mentioned above, following five programs have been proposed as the basic strategy for disaster risk management for N-M Highway.

I. Additional Structural Measures

II. Regular Maintenance and Quick Response

III. Maintenance of Sabo Facilities

IV. Road Early Information System

V. Disaster Mitigation Activities in Communities

I. Additional Structural Measures

Implementing additional countermeasure

Nine (9) sites which were estimated to have potential economic risk over one million Rs/year was selected to be implemented additional countermeasures. By implementing these countermeasures, potential economic loss induced by sediment-related disasters would reduce 36 million rupees and total potential economic loss would be 70 million rupees from current risk of 106 millions rupees.

The total construction cost for the additional countermeasures is estimated around 200 million rupees.

II. Regular Maintenance and Quick Response

Regular road maintenance is already systemized DOR and executing steadily according to Annual Road Maintenance Plan. Cleaning of drainages and slope protections are effective to reduce collapses of river side slopes under heavy rain and protection for pavement. Existing quick response and reopening system is being executed according to yearly plan of operation made by DOR.

III. Maintenance of Sabo Facilities

Formulation of maintenance of sabo facilities was newly proposed in the study. Inventory survey of sabo facilities to formulate the system is being implemented by DWIDP and the system has been finalized.

IV. Road Early Information System

Road Early Information System has been formulated which provides early warning of disaster occurrence and traffic congestion. This system has been operated since July, 2008 through pilot project to verify effectiveness of the system. It is expected that reduction of fatal traffic accident induced by disasters and useless traffic congestion.

V. Disaster Mitigation Activities in Communities

Disaster mitigation activity in Kabilash Village was formulated and implemented in the pilot project.

1) Hazard mapping
2) Disaster education
3) Early Warning/ Evacuation System
4) Simple structural measures
5) Forestation planning and countermeasure planning

Activities listed above were prepared and being carried out in the pilot project. This system contributes not only to reduce casualties induced by road slope disasters but also improve village life and safety.

9.1.3 Implementation Cost for Basic Strategy

Initial investment for implementing the basic strategy is around two hundred million rupees which is mostly allotted for the additional countermeasures that will be implemented by DWIDP and DOR.

9.1.4 Sabo Planning for Ruwa Khola

(1) Risk Condition of Ruwa Khola

Existing sabo dams which were constructed by DWIDP are effective to prevent small amount of debris flows. But, collapse of unstable slopes of upper stream under heavy rains will generate big amount debris flows which can not be controlled by the preventive function of the existing sabo dams. Hence, when the same level of heavy rainfall would induce such debris flow disasters, Marsyangdi Power Plant economic loss would be estimated to be around 5 million rupees per year.

(2) Countermeasure Planning

Considering the hazard condition and risk level of Marsyangdi Power Plant, countermeasures for protecting the power plant has been planned as below:

a) Removal of soils in the sabo dams; 8,500 m^3

b) Concrete walls to protect the power plant; right bank: 207 m; left bank: 57 m; total: 267 m

9.1.5 Formulation of Implementation Organization

(1) Implementing Organization for Structural Measures

After the disaster, the DOR executed rehabilitation works for mainly river side slopes, and DWIDP implemented preventive sabo dams for debris flows which were very effective for the heavy rainfall in 2006. This shows that it similar cooperation between DOR and DWIDP for road disaster management in the future is necessary.

(2) Implementing Organization for Maintenance

Chitwan DRO had carried out road disaster management according to the yearly maintenance plan until 2003 disasters and will manage the maintenance in the future. DWIDP will organize and implement the maintenance for the sabo facilities.

(3) Implementing Organization for Road Early Information System and Disaster Mitigation Activities in Kabilash Village

"Planning and Review Committee (district level)" and "Advisory Committee (central level)" on Chitwan District Disaster Management Partnership have been formulated with concerned organizations and key personals; DOR/MOPP, DWIDP/NOWR, PSSD/MOHA, DoLIDAR/MOLD as Advisory Committee and CDO, SP of Police Office, Division Chief/Road Office, PM/MNWIDPP etc.

This committee managed and operated the road early information system and disaster mitigation activities in Kabilash Village.

9.2 Recommendation for Self-Supported Sustainability

9.2.1 Continuous Implementation of Basic Strategy

Five programs with the basic strategy on disaster risk management for N-M Highway were formulated considering the actual risk level and economic feasibility of the target area. These programs shall be implemented continuously to maintain credible traffic function and road safety.

9.2.2 Application of Basic Strategy for National Road Section

The basic strategy on road risk management was formulated by focusing on the 36 km of the N-M Highway. But, methodology in the basic strategy can be applied for road sections which have similar issues on road disaster management.

It is recommended to apply of the basic strategy for 5,000 km of the strategic road net work in Nepal and formulate reasonable road disaster information system.

9.2.3 Development of Disaster Information System

The disaster information system (Road Early Information System and Early Warning/

Evacuation System) was formulated and operated. Considering evaluation of the pilot project, following 12 matters are suggested and recommended to make self-supporting, sustainable systems.

(1) System operation as a session in the "Chitwan District Disaster Management Preparedness Committee"

It is recommended that this committee on road early information system and early warning/ evacuation system shall be operated as part of the session of abovementioned "Chitwan District Disaster Management Preparedness Committee" chaired by CDO, since the said committee is being operated by all concerned official organizations, NGOs and villagers. This disaster information system shall be informed district wide. It is expected that this system would be supported and advised by the members of the preparedness committee.

(2) Opening the committee twice a year

- Review Committee after rainy season
- Planning Committee before rainy season (May)

Operation of the system shall be reviewed every year just after rainy season to discuss lessons learned of the preceding year. Moreover, before rainy season, result of review committees operation plans shall be discussed by implementing organizations to build-up practical operation system of the year.

(3) Execution of drill

Drill of the system operation shall be carried out after the planning committee confirm the plan of operation for the year and strengthen information network among concerned organizations.

(4) Increasing of computer operator

Each organization assigns staffs for the total implementation of the system at present. However, persons who possess adequate ability in operatin computers are very limited in the organization. Moreover, the staffs are too busy with other ordinary tasks to be able to concentrate on operating of the system, especially during rainy season. Therefore some persons should be trained to operate the computers in the future.

(5) Brush up of operation plans of next year

Operation plans for the next stages was made up by the DPO, DRO and Kabilash Village as reported in the former session. However, the plans can be further refined for its actual operation, which do not seem to involve considerable work.

(6) Operation on Kabilash Village

The Team understands that human resource and budget is limited to operate the early warning and evacuation system. However, it is expected that the system shall be operated considering the condition of the village, i.e., a real “community based disaster management”.

(7) Role of advisory committee (central level) in the future

Advisory committee is composed of MOHA, DoLIDAR, DOR and DWIDP. The advisory committee provides input on the technical advice to the implementing organization of road early information system and early warning/ evacuation system for Kabilash Village. The system operation shall be supported by following the action that was conducted by the advisory committee;

- Checking the system and request holding Planning Committee before rainy season
- Request for holding Review Committee after rainy season
- Presentation and discussion on the system in “Chitwan District Disaster Management Preparedness Committee”
- Advice on reviews and plan of operations

Through the activities mentioned above, the committee grasps the know-how of these new system and understanding of financial support requirement on central level.

(8) Role of DWIDP

DWIDP shall call the advisory committee. It shall coordinate the review of the systems after rainy season, and the planning of the systems before rainy season. DWIDP also shall make presentation about the reviews and the planning of the systems on Chitwan Disaster Management Preparedness Committee (CDMPC).

DWIDP also provides advises on water-induced disaster management policy and methodology/ equipment maintenance.

(9) Early warning for serious disturbance

NMHEIS started the early warning for heavy rain and traffic obstacle (road closure and traffic jam) information. However it can be modified in case of treating early warning for serious disturbance such as rock slope failure at km 29+800 on 14th August 2008. DPO should issue early warning when danger situation for traffic is recognized.

(10) Improvement of notice board

There are some drivers who can not read Nepalese alphabet. Hence, illustrations can be one of the means of notifying motorists. However, this should be subject to further discussion by

CDMPC.

(11) Public awareness

It may be effective for DPO to conduct seminars on the Road Early Information System and traffic manners to enhance the awareness and the effectiveness for drivers and road users.

(12) Financial plan for the systems operation

As a plan to secure the finances, imposing fee for advertising could sustain implementation of the systems. This is subject to discussion by CDMPC regarding practical collection method and corresponding expenditure.

These systems can be applied for district wide disaster management to reduce casualties of water induced disasters.

9.2.4 Technical Advice on Countermeasure Works

Generally, countermeasure works for debris flow and slope protection are being implemented suitably. However, some existing preventive structures were damaged with preventive functions degraded. It is considered that the cause of some of the poor countermeasure works are due to unsuitable application of planning/designing and inadequate construction works. It is important that basic technical procedures should be reaffirmed and instructed to engineers in charge of planning/designing/construction as described in “Technical Guide of Sabo and Road Slope Protection”.