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.

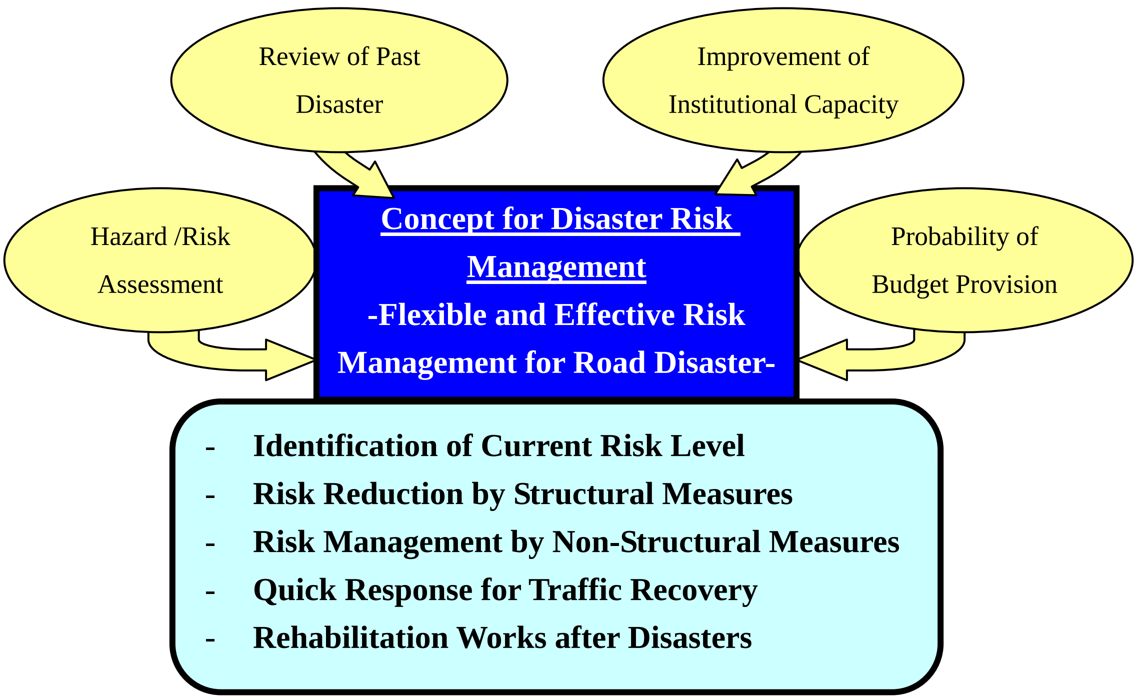


Figure 4.1.1 Concept Formulation of Disaster Risk Management

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.

The risk before 2003 disasters and current total risk has been estimated 34.7 FRCDp (RCDs/year), 194 ALp (million Rs) and 22.0 FRCDp (nos/year), 106 ALp (million Rs) respectively as shown in the Table 4.1.1.

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%

Drastic improvement of risk level of current situation compared to 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.

4.1.3 Policy to Plan Basic Strategy

Components of basic strategies are shown in Figure 4.1.2.

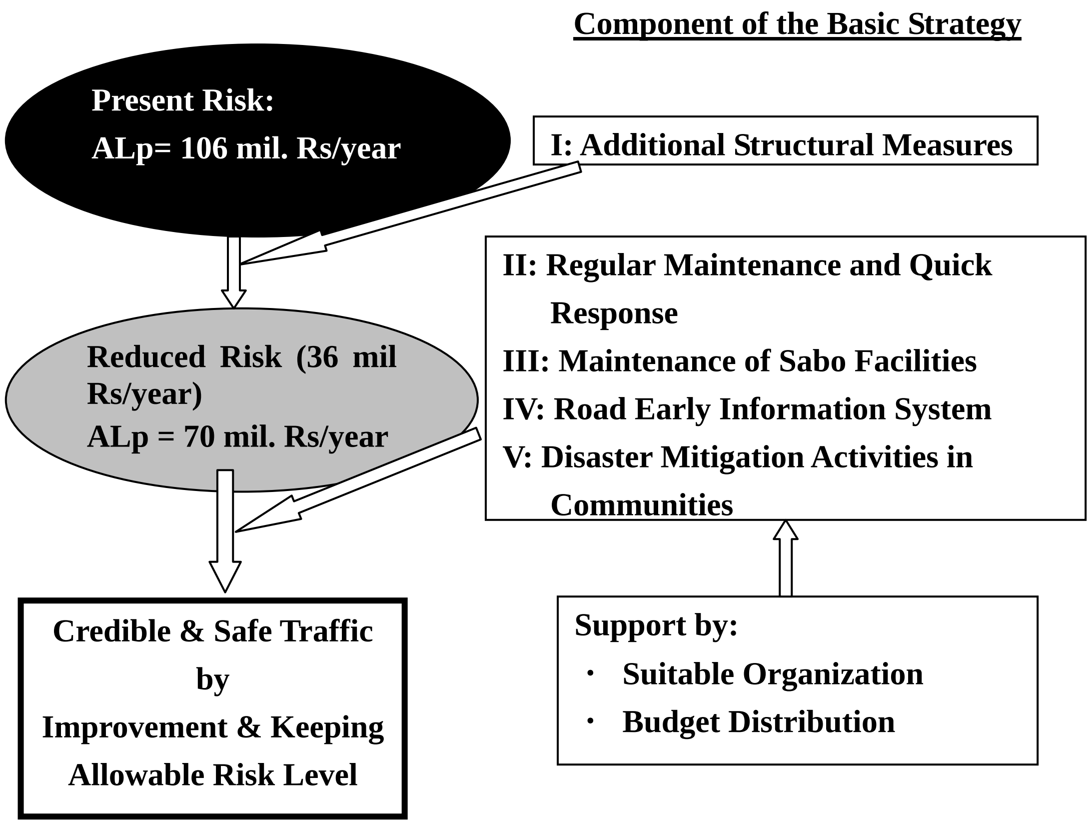


Figure 4.1.2 Components of the Basic Strategy and Risk Management

Results of risk estimation indicated that the implementation of structural measures after 2003 disaster achieved 45% decrease in ALp compared to the 2003 disasters. Under 2006 heavy rainfall which return period is around 10yrs, no serious traffic disturbance happened.

So, in consideration of the effectiveness of structural measures mentioned above, Basic Strategy is planned to strengthen and maintain current preventive facilities by implementing additional measures and soft measures. Each item in detail of the Basic Strategy is described as follows:

1) Additional Structural Measures

High-risk sites with ALp of more than 1.0 million Rs which is accounting for 47% of overall ALp of the total section is selected and structural measures are implemented to decrease ALp from 106 million Rs to 70 million Rs.

2) Regular Maintenance and Quick Response

Measures to prevent occurrence of sediment related disasters have been constructed after 2003 disasters by DOR and DWIDP that improved drastically traffic function of N-M Highway. But, to keep this condition, continuous maintenance works are indispensable.

3) Maintenance of Sabo Facilities

Sabo dames, which constructed from 2004 to 2007, contribute risk reduction. Disposal of accumulated sand is most important and efficient procedure and priority method.

4) Road Early Information System/ 5) Disaster Mitigation Activities in Communities

'Road Early Information System' and 'Disaster Mitigation Activities in Communities' are introduced components of basic strategy which evaluated by pilot projects. Even after implementing additional countermeasure, road disaster potential still remained. So, risk management utilizing soft measure such as road information system is proposed in the basic strategy.

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. If these slopes were protected by sufficient countermeasures, the total ALp of N-M Highway would be reduced to 70 (=106－36) million Rs/year, which is 36% (=70/194) of ALp before 2003 disasters.

4.2.2 Selected Sites for Preventive Structural Measures

It is judged by the risk evaluation that serious slope disasters are not occur in other slopes. So, the target of risk reduction set for the twelve site of that ALp is higher than 1.0 million Rs/year. Selected sites include six mountainside slopes and six crossing streams. Preventive structural measures and economical evaluation were studied on these 12 sites.

Table 4.2.2 Selected Sites of Preventive Structural Measures

Location of Mountainside Slopes	Location of Crossing Streams
21km+610 SL-1: landslide-1	11km+200 Kahale Khola
23km+510 SL-2: landslide-2	11km+500
23km+960 SL-3: landslide-3	12km+600 Dash Khola
24km+235 SL-4: landslide-4	21km+200
30km+690	21km+560
34km+200	23km+930

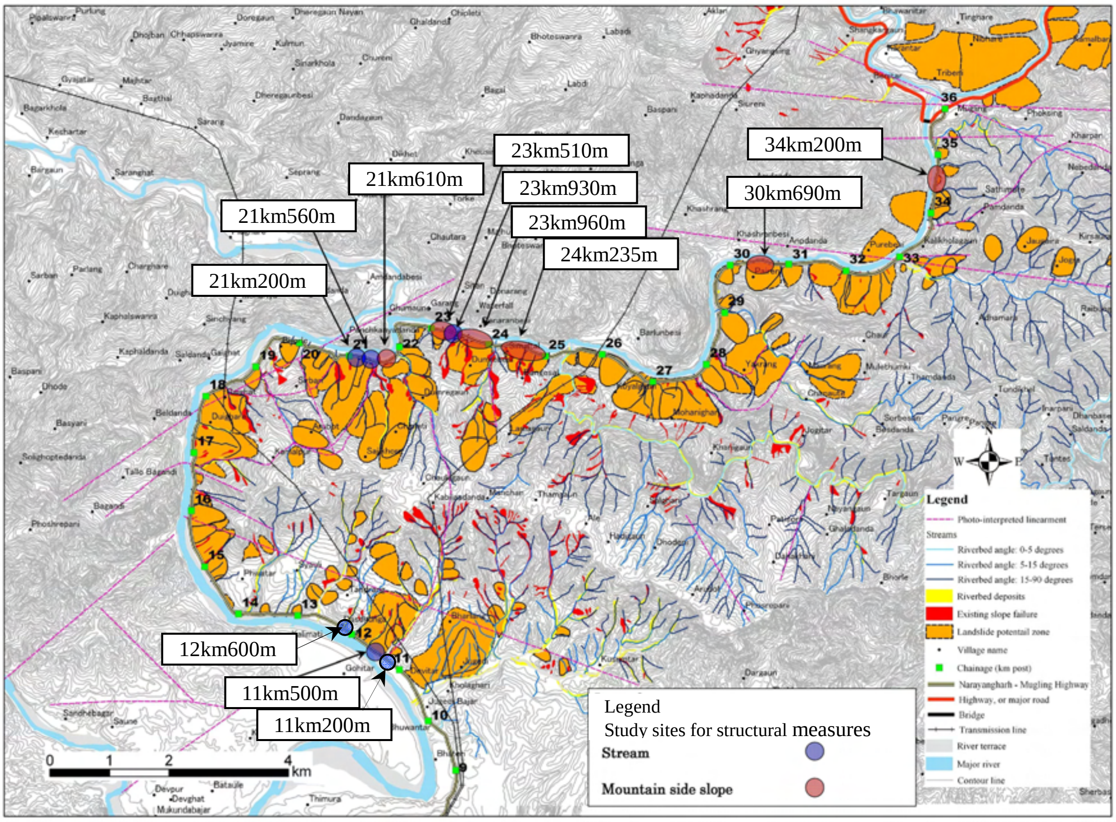


Figure 4.2.1 Locations of the Selected Sites to Deliberation of Additional Countermeasure

4.2.3 Preliminary Design and Cost Estimation

At crossing stream 21km+560, sediment removable work can reduce potential annual loss under 1 million Rs/year, therefore, the site is not necessary of additional preventive countermeasure.

MNWDPP conducts ongoing sabo works (2007- 2008) at 11km+280 Kahale Khola and 12km+600 Dash khola. These works are summarized in Tables 4.2.3. Potential annual loss of two sites will be under 1.0 million Rs/year after the sabo works. Therefore, the two sites are not included in additional preventive work sites. (refer to Volume III Data and Drawing)

Table 4.2.3 Summary of Two Crossing Stream Ongoing Sabo Works by DWIDP

Location	Slope Type (Disaster Type)	Potential Annual Loss (mil. Rs/year)	Sabo Works	Cost	BCR: Benefit Cost Ratio
11km +280 Kahale Khola	Crossing Stream (Debris Flow)	Before 5.774 After 0.577	220m upstream from the road Concrete sabo dam 73m length 5m height	7,300,000	2.4
			310m upstream from the road Concrete sabo dam 43m length 5m height	4,300,000	
			825m upstream from the road Concrete sabo dam 45m length 7m height	6,300,000	
			1km 300m upstream from the road Concrete sabo dam 38m length 8m height	6,080,000	
			1km 750m upstream from the road Concrete sabo dam 30m length 7m height	4,144,000	
			125m upstream from the road right bank Concrete spur	418,000	
			Total	**28,542,000**	
12km +600 Dash Khola	Crossing Stream (Debris Flow)	Before 7.661 After 0.766	310m upstream from the road Concrete sabo dam 80m length 7m height	11,200,000	2.6
			520m upstream from the road Concrete sabo dam 71m length 7m height	9,940,000	
			915m upstream from the road Concrete sabo dam 50m length 7m height	7,000,000	
			1km 125m upstream from the road Concrete sabo dam 33m length 7m height	4,620,000	
			0-125m upstream from the road canalization	2,500,000	
			0-300m upstream from the road left bank Gabion spurs	1,000,000	
			Downstream of bridge, to wall of random rubble masonary, 30 meter length, 2 meter height	3,000	
			Total	**35,660,000**	

The study observed and planned of preventive structural countermeasure on remaining 9 sites (Refer Volume II Data and Drawing 6. Road Slope Assessment Sheet of Twelve Priority Road Segment and 8. Structural measure Design and Cost Estimation)

In countermeasure designing following policy is applied:

a) Methods generally used in Nepal, such as horizontal drain holes work, sabo dam, gabion, and so on

b) In the cases of a little or no effect for disaster prevention, typical methods in Japan were introduced as new ones, such as concrete crib work, rock fall prevention net and fence, and so on.

Total cost of preventive structural countermeasure is 204 million Rs.

Economic indicator shows that all of nine sites are economically feasible.

The result of planning of countermeasures/cost estimation is shown in the Table 4.2.4.

Table 4.2.4 Selected Sites for Implementing Preventive Structural Countermeasure

Location	Slope (Disaster Type)	ALp mil. NPR/year	Recommended Measures		Cost	BCR: Benefit cost ratio
21km +200	Crossing stream (SF/DF)	Before 2.653 After 0.796	Concrete retaining wall	113.39 m^3	527,859.0	23.6
			Rock fall protection fence	22.0m	377,663.0	
			Demolishing of existing wall	19.5m	13,934.0	
			×1.13（13％VAT）		**1,038,985.0**	
21km +610	Mountainside slope (SL)	Before 2.863 After 0.716	Horizontal drain holes	486.0m	5,728,880.0	4.4
			×1.13（13％VAT）		**6,473,634.0**	
23km +510	Mountainside slope (SL/SF)	Before 3.492 After 0.715	Shotcrete crib work	4196.6 m^2	14,318,696.0	1.5
			Rock bolt work	3671.50m	5,398,327.0	
			Seed-mud spraying work	3032.06 m^2	6,506,910.0	
			×1.13（13％VAT）		**29,633,044.0**	
23km +930	Crossing stream (DF)	Before 2.286 After 0.686	Gabion mat	825.69 m^3	1,607,117.0	11.7
			Removal of deposits	2,730m^3	—	
			×1.13（13％VAT）		**1,816,042.0**	
23km +960	Mountainside slope (SL)	Before 13.749 After 0.687	Shotcrete crib work	20269.72 m^2	68,930,851.0	1.2
			Rock bolt work	17734.5m	26,000,153.0	
			Seed-mud spraying work	14644.87 m^2	30,774,324.0	
			×1.13（13％VAT）		**142,047,020.0**	
24km +235	Mountainside slope (SL/DF)	Before 1.523 After 0.381	Horizontal drain holes	150.0m	1,770,488.0	7.5
			×1.13（13％VAT）		**2,000,651.0**	
30km +690	Mountainside slope (SF)	Before 1.898 After 0.285	Shotcrete crib work	2433.94 m^2	8,466,350.0	1.6
			Seed-mud Spraying work	1690.24 m^2	3,660,422.0	
			×1.13（13％VAT）		**13,703,252.0**	
34km +200	Mountainside slope (RF)	Before 4.347 After 0.652	Rock fall protection net	4150.0m^2	6,180,463.0	7.0
			×1.13（13％VAT）		6,983,923.0	
8 sites		Before 32.811 After 4.377			**203,696,551.0**	2.0

4.2.4 Implementation Plan

F/S for N-M Highway has been done within the Maintenance and Development Project (MDP), Sector Wide Road Programme and Priority Plan Study, which is financed by the World Bank. However, an agreement to finance for the implementation of the Maintenance and Development Project has been not yet reached between the Government of Nepal and the World Bank.

Therefore, implementation plan for structural measures in this F/S are formulated, taking no account of the above-mentioned Maintenance and Development Project.

(1) Available Technology and Equipment in Nepal

Table 4.2.5 lists the selected sites together with the proposed works for each site. In addition, the site No. 1 (11km+500) has been planned to be implemented as pilot project.

Table 4.2.5 Selected Sites and Proposed Structural Measures for Each Location

Site No.	Location	Works	Remarks
1	11km+500	・ Bio-engineering/wicker work ・ Gabion check dam work	Pilot project
2	21km+200	・ Catch wall＋Rock fall protection fence	
3	21km+560	・ Removal of deposits	No structure
4	21km+610	・ Horizontal drain holes work	SL-1
5	23km+510	・ Shotcrete crib work with rock bolt ・ Seed-mud spraying work	SL-2
6	23km+930	・ Gabion mat work ・ Removal of deposits	
7	23km+960	・ Shotcrete crib work with rock bolt ・ Seed-mud spraying work	SL-3
8	24km+235	・ Horizontal drain holes work	SL-4
9	30km+690	・ Shotcrete crib work	
10	34km+200	・ Rock fall prevention net work	
11	Ruwa Khola	・ Revetment type guide concrete wall ・ Removal of deposits	

As shown in Table 4.2.5 above, the major work items proposed in the Study can be carried out by local contractors in terms of available technology and equipment and recent experience. Following three countermeasure works are required to pay special attation :

(a) Shotcrete crib work,

(b) Shotcrete crib work with rock bolt work, and

(c) Rock fall protection net work

The former two works require experienced contractors for the purpose of guarantee of quality and functions for the works. Execution of shotcrete cribs are done with spraying equipment and the installation of rock bolt is needed drilling equipment, such as auger drilling and leg hammer drilling. Some local contractors have certain experience in the construction of shotcrete crib work under the supervision of international consultants.

Rock fall prevention net work is the preferred solution to mitigate the damage of rock fall, especially in mountainous countries like Nepal. Its application provides the opportunity to expand the base of the contractor's experience in the country.

(2) 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 4.2.6.

Table 4.2.6 Arrangement of Selected Sites for Implementation

Package	Location	Works	Cost (mil.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.

(3) Construction Procedures

Most of the proposed works are common in Nepal. Local contractors have much experience in implementing them under the management of DWIDP or DOR. Therefore, construction procedures focus on crib work and rock fall protection net work, as shown in Figures 4.2.2 to 4.2.4.

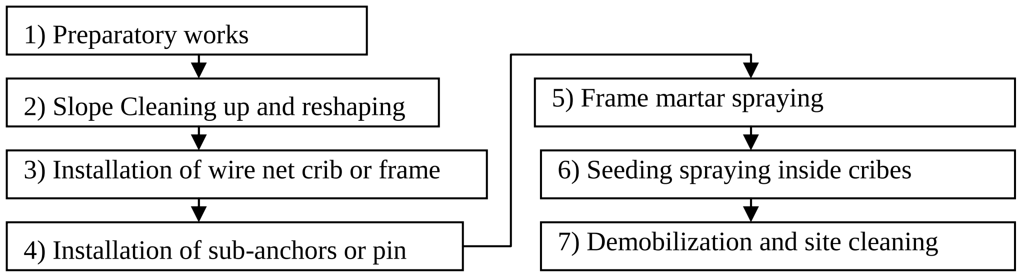


Figure 4.2.2 Procedure of Shotcrete Crib Work Construction

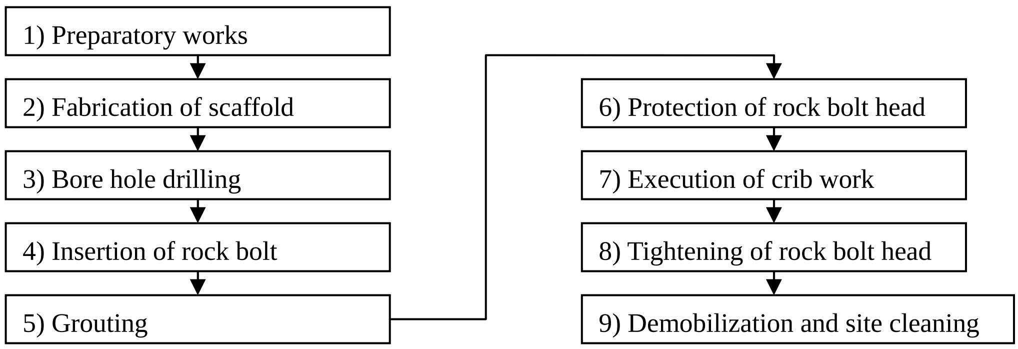


Figure 4.2.3 Procedure of Shotcrete Crib Work with Rock Bolt Construction

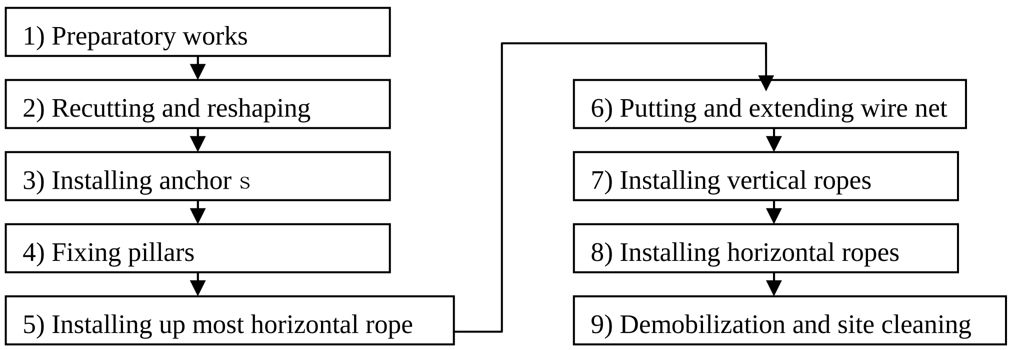


Figure 4.2.4 Procedure of Rock Fall protection Net Work Construction

(4) Construction Schedule

Figures 4.2.5 and 4.2.6 show the overall construction schedule for Package I/III and Package II, respectively.

For the purpose of construction quality guarantee, construction of works begins after rainy season (after September) and terminate before next rainy season (before July).

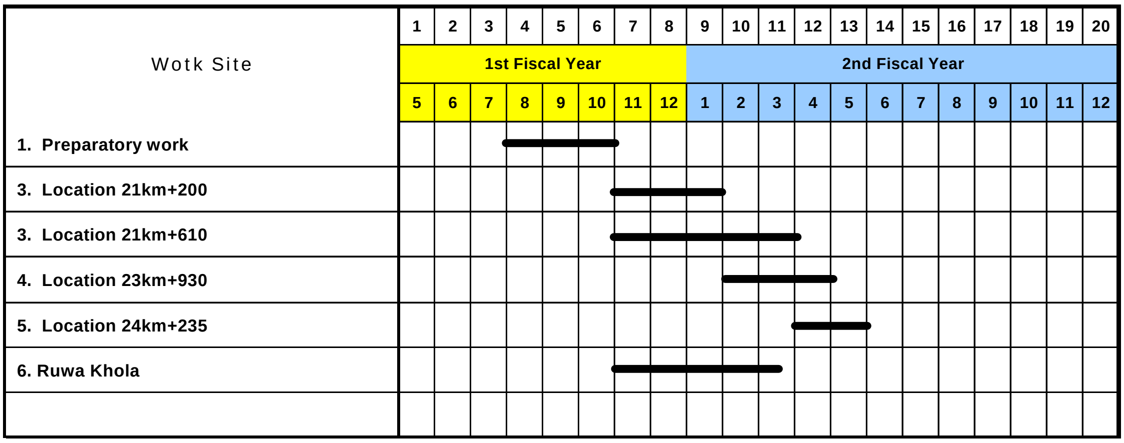


Figure 4.2.5 Overall Construction Schedule for Package I and III

In implementing the Package I and III, conditions of construction is considered as follows:

(a) Three parties shall carry out the construction of the all works in the Package, namely, the first party for Locations 21km+200 and 23km+930, the second party for others.

(b) Drilling for installing horizontal drain holes is assumed to be 5m/day.

Similarly, conditions of construction for the Package II is considered as follows:

(a) Two parties shall carry out the construction of the all works in the Package, namely, the first party for Location 23km+510, and the second party for other locations.

(b) Location 23km+960 shall be implemented in another fiscal year after the completion of the other locations.

(c) The drilling method used for installing rock bolts is assumed to be leg hammer drilling. For Location 23km+510, 5 leg hammer drillings shall be used with a working speed of 2 rock bolts per day, whereas, for Location 23km+960, 10 leg hammer drillings shall be used with a working speed of 3 rock bolts per day because of experience.

(d) During drilling for rock bolts and inserting of rock bolts, installation of wire net frames and mortar spraying shall be carried out simultaneously in the separate working areas.

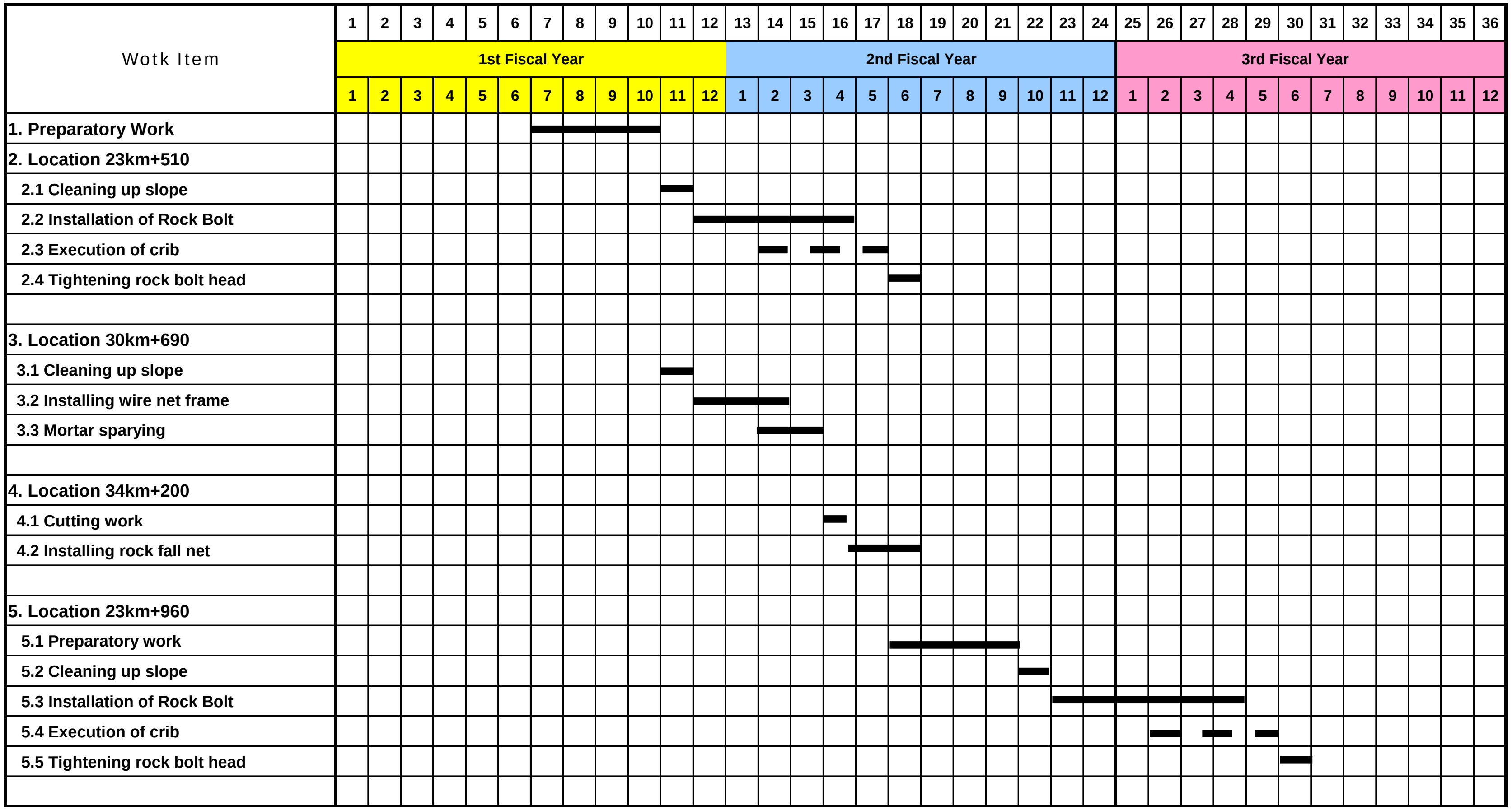


Figure 4.2.6 Overall Construction Schedule for Package II

4.3 Regular Maintenance and Quick Response

Measures to prevent occurrence of sediment related disasters have been constructed after 2003 disasters by DOR and DWIDP that improved drastically traffic function of N-M Highway. But, to keep this condition, continuous maintenance works are indispensable.

(1) Road maintenance including routine, recurrence, emergency

(2) Maintenance works for sabo dams in streams across the Highway

The system on road maintenance including routine maintenance, recurrence maintenance is already formulated by DOR and the road maintenance for the Highway is being executed steadily and successively. The outline of existing maintenance system is summarized referring the “Annual Road Maintenance Plan for 2008/2009 (Draft/Request)” prepared by Division Road Office Bharatpur, Chitwan and some recommendation on the system is described in this section.

On the other hand, maintenance system for sobo facilities is not established at present. Construction of check dams to prevent debris flows affecting traffic functions of the Highway started in 2004 and being implementing. These check dams are very effective at present that was proved by no road closure under heavy rainfall in 2006. But, the capacities of check dams are almost filled up by the 2006 debris deposits that will not be able to prevent the next debris flow induced by heavy rainfall in the near future. So, maintenance work for check dams is essential to keep the effectiveness to prevent road closure by debris flow.

Maintenance system for sabo facility is proposed in this section

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, Bharatpur along with “Annual Road Maintenance Plan” prepared in February 2008.

(1) Role of the Division Road Office, Bharatpur and its Organization

Division Road Office, Bharatpur is responsible for maintaining strategic roads in Chitwan and Dhading districts. Roads being administrated by the Office are 264.27km of Strategic Network including 36.16km of N-M Highway. The Office is also involved in the construction of major bridges within these districts under the organization shown in the Figure 4.3.1.

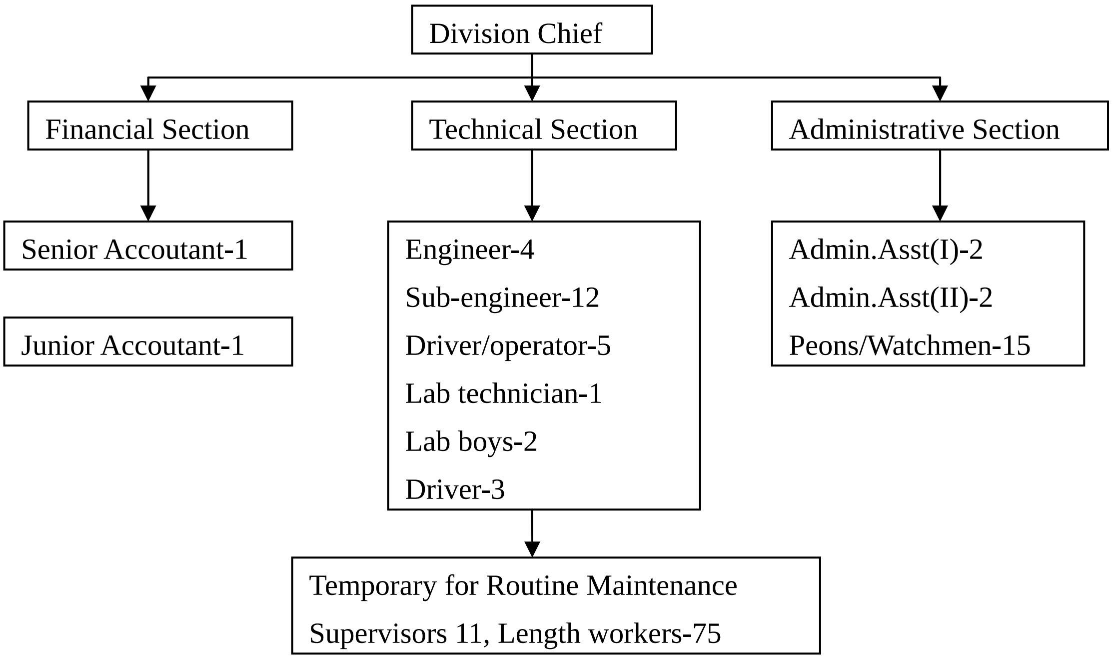


Figure 4.3.1 Organization of Division Roads Office, Bharatpur

(2) Preparation of Annual Road Maintenance Plan on Sediment Related Disasters

The ARMP (Annual Road Maintenance Plan) is prepared in accordance with the standard ARMP guidelines provided by Strengthened Maintenance Divisions Program which include all items on road maintenance such as bridge or pavement.

The annual maintenance plan is formulated based on the information obtained seasonal inspection after rainy season and maintenance/disaster record. Flow of planning annual maintenance plan on sediment related disaster is shown in the Figure 4.3.2.

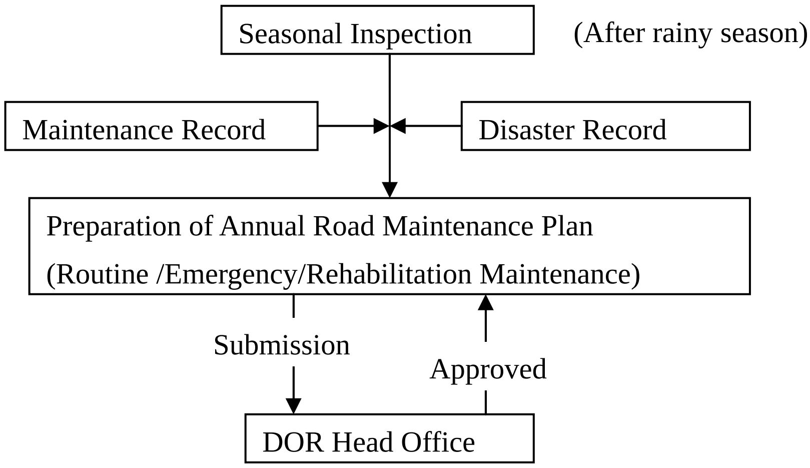


Figure 4.3.2 Flow of Preparation of Annual Road Maintenance Plan on Sediment Related Disasters

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

Total around 25 million Rs is proposed in the ARMP 2008/2009 for N-M Highway which is around 9.6% of total maintenance budget of the Road Office.

Table 4.3.1 Planned Maintenance Works for N-M Highway

Maintenance Item	System/Activities	Budget Requested for 2008/2009 (Rs)
(a) Routine Maintenance	- Length workers are employed for 0-18km and 18-36km section respectively, - Clearing road and drainage are major activity.	330,139
(b) Recurrent Maintenance	Following repair works are implemented by Performance Based Road Maintenance Contract - Removal of debris under bridge, - Shoulder repair, - Culvert/stone masonry works, - Gabion wall repair, - Repair masonry/earthen drain, - Embankment/filling, - Bio-engineering.	12,850,000
(c) Rehabilitation Works	Sub grade preparation/Base course/Tack coat/40mmasphalt concrete/ Side drain/RRM in 1.4 CSM	11,594,822
(d) Bio-engineering & Other Works	Bio-engineering & Other works	36,897
(e) Emergency Works	-Emergency work is executed along with "Yearly Emergency Action Plan". -The work is handled from four locations; Naubise, Gajuri, Mugling and Bharatpur. - A crew of technical and other staffs along with a fleet of machines and equipment are deployed at these 4 locations. - Approximately following machines and personnel at these location is allocated. - Equipment ・Wheel loader-1 ・Tipper/tractor-1 - Human recourses ・Engineer-1 ・Sub-engineer-1 ・Operators- 2 ・Other supporting staff- 4	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.

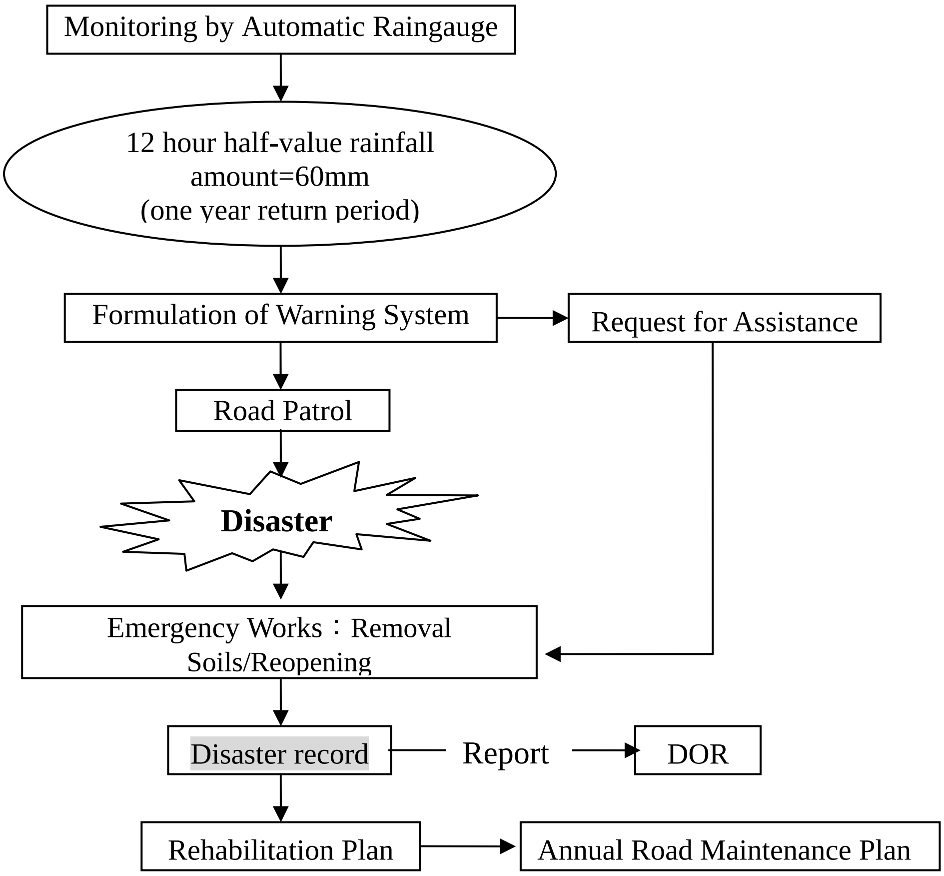


Figure 4.3.3 Flow of Emergency Works

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

(1) Removal of Deposits

Because of limited sedimentation capacity, the existing sabo dams have been malfunctioned with sedimentation behind the dam. In order to protect the traffic safety from debris flow, construction of new sabo dams or functional recovery of existing sabo dams are necessary. In generally, the functional recovery of an existing sabo dam by removing the overall or partial deposits behind the dams are much cheaper than construction of a new sabo dam, especially with respect to mountain roads. The functional recovery of an existing sabo dam by removing deposits is one of the most important and cost-effective methods for sabo dams.

A number of sabo dams were constructed by DWIDP after the 2003 disaster. These sabo dams considerably contributed to mitigation of disasters in the 2006 heavy rainfall. However, these sabo dams were mostly filled up with deposits and had not enough capacity to cope with the next large disaster such as the 2003 or 2006 disasters. Therefore, the functional recovery for the existing sabo dams by removing deposits should be done immediately and continuously.

(2) Repair of Sabo Facilities

Based on field inspection, the existing sabo dams and other sabo facilities had some damage and defects as follows:

- Damage of gabion mesh wire
- No foundation work for dam body were executed
- Settlement and inclination of dam body due to scouring of foundation
- No protection on the crest part of gabion sabo dams from damaging by debris flow deposits was made
- Flow sections near the road were not enough to discharge the expected debris flow
- Others

Without repair of the above-mentioned damage and defects, the existing sabo facilities could not show the original function and capacity. This probably caused the occurrence of damage.

In this Study, the potential annual loss estimation and hazard evaluation was done on the condition that the existing sabo facilities had the originally designed functions and capacity. If repair of sabo facilities were not done, the present effectiveness of the existing sabo facilities would be very small or zero, and therefore new sabo facilities as alternative facilities should be implemented.

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

1) Inspection of Sabo Dams

Inspection of sabo dam shall be carried out once a year after rainy season and shall make a list of dams which is required to remove deposits or to be repaired.

2) Removal/Repair Planning

The yearly maintenance plan shall be made and submitted to DWIDP head office.

3) Approval of DWIDP Head Office

Yearly plan of maintenance works shall be judged its feasibility by the head office of DWIDP and approved to implement.

4) Implementation of Maintenance Works

Maintenance shall be implemented along with the yearly maintenance plan.

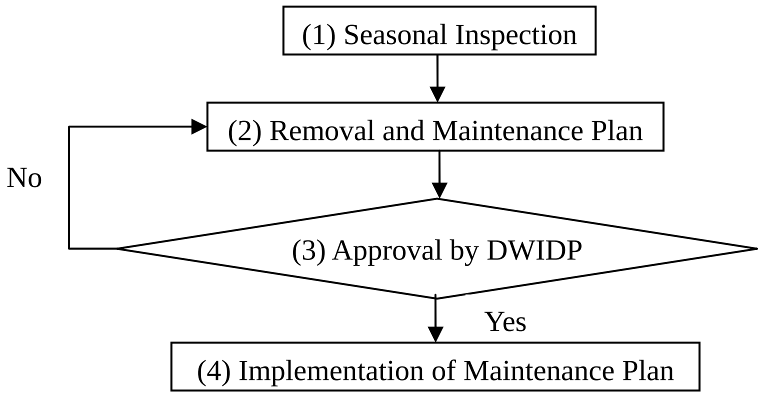


Figure 4.4.1 Flow of Maintenance Works for Sabo Dams

4.4.4 Outline of Removal of Deposits

(1) Selection of priority crossing streams

Sabo dams subjected to removal of deposits were as follows:

- Sabo dams within about 100 m far from the road, in consideration of the easy access and these dam having mainly catch capacity of deposits
- Sabo dams in the upstream were excluded because they had the same function as embankment to protect the toe failure of slope

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+ 200 (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.

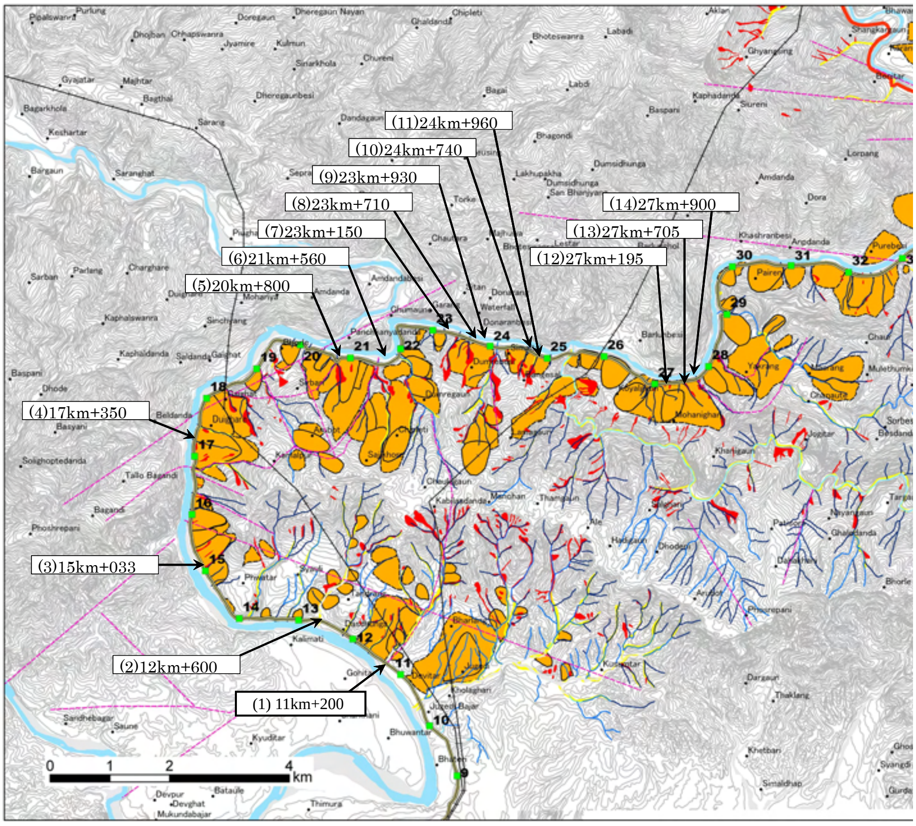


Figure 4.4.2 Location of Sabo Dams Needed to Remove Deposits

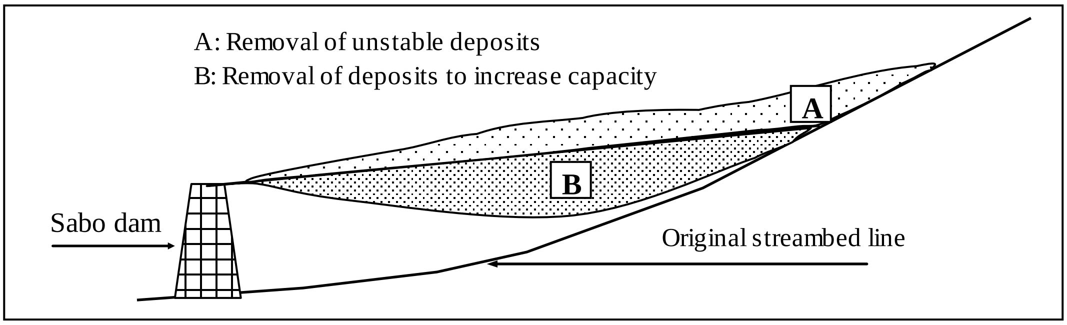


Figure 4.4.3 Conceptual Illustration of Functional Recovery for Sabo Dam

(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. Result of surveyed is shown in Figure 4.4.4 (source: Contract No: MNWIDPP-C-01/064/65 Preparation of Asset Inventory of MNWIDPP).

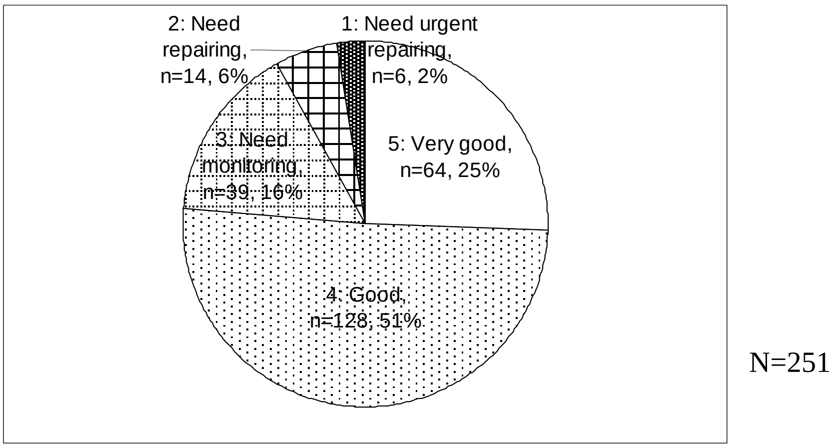


Figure 4.4.4 Result of Inventory Survey on Facility of Disaster Preventive Works

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.

Figure 4.5.1 Target Areas for Risk Management by Road Early Information System

4.5.3 Outline of the System

(1) General System

Road Early Information System was formulated as shown in Figure 4.5.2.

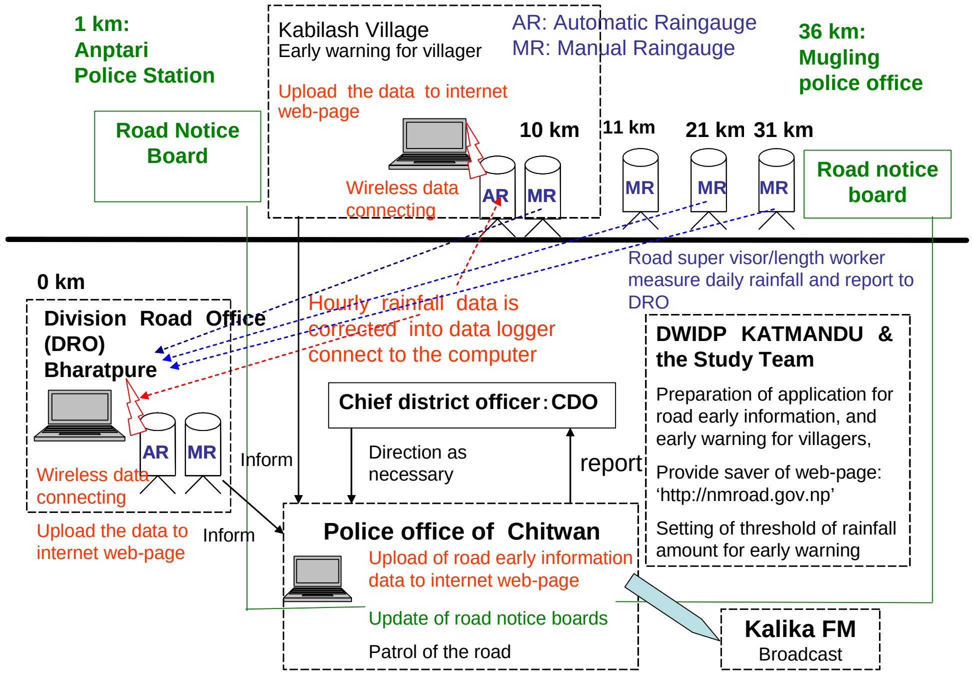


Figure 4.5.2 Schematic Chart of Formulated Road Early Information System

The system is composed of a computer for analysis and monitoring, seven raingauges including automatic type with microwave sensor or , micro wave receiver and two notice boards. The automatic type raingauge monitors rainfall intensity at anytime which is sent by micro wave to the monitoring center. Divisional Road Office, Chitwan monitors rainfall data that is analyzed by operating the computer to make decision for early traffic information. Final decision for public notice is done by the SP of DPO.

This system is utilized as early warning system for villagers by applying another criterion for evacuation.

Table 4.5.1 Devices Composed of the System

Device	Nos.	General Specification	Installing Location
Raingauge	5	Manual	0, 10, 11, 21, 31km
Raingauge	2	Automatic with micro wave censor or CDMA	10km and DRO
Receiver(micro wave censor)	2		DRO, Kabilash Village
Computer	3	CPU-2GZ, Core 2Due, RAM -2GB HD-120 GB, O/S- Windows Vista Monitor- 14", Drive-R/W	DRO, DPO, Kabilash VDC
Notice Board	2	Manual board	1km and 36km

(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 as shown in the Table 4.5.2.

Table 4.5.2 Contents of Road Early Information

Traffic obstacle status	Section of traffic obstacle	Predicted duration of the obstacle	Phenomena
Road closure Traffic jam	From CH xx To xx	From xx Hour xx Day xx Month 2008 Until xx Hour xx Day xx Month 2008 or Not clear of duration	- Slope disaster - Traffic accident - Strike - The other
Potential road closure/traffic jam			- Schedule of strike - The other
Early warning/caution by heavy rain		From xx Hour xx Day xx Month 2008	- Notice by threshold of 12 hour half-value rainfall amount

(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 4.5.3. 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 4.5.3 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

"Chitwan District Disaster Management Partnership Committee" was formulated. The committee executes general management and make plan of operation of the system.

Chairman of the committee the CDO, Chitwan and members are composed of SP of Division Police office, the chief of Division Road Office Bharatpur, Chitwan, representative of MNWIDPP and /or No3. Division of DWIDP, representative of the press and, etc.

Role and activities of the committee are as follows;

- 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 Organization

Chief of Divisional Office, Divisional Police Office, Divisional Road Office and Kabilash VDC are major players to operate the Road Early Information System. Their roles to operate the system are as follows:

1) CDO

CDO is the chairperson who manages the committee totally and makes final decision of operation plan.

2) DPO

Roles of DPO are as follows

- 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

DRO monitors five (one automatic and four manual) raingauges and analyzes rainfall monitoring data by operating computer. Roles of DRO are follows.

- 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

Kabilash VDC monitors two raingauges and analyzes rainfall monitoring data by operating central computer. Roles of Kabilash VDC are follows.

- 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, Mugling-Narayangharh Water Induced Disaster Prevention Project (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 4.5.4. Annual cost is 150,000

Rs/year. Cost for required staff is not included in the table.

Table 4.5.4 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

Benefit of Road Early Information System includes as follows;

- 50% of potential annual human lives loss and potential annual vehicle loss due to road closures disaster
- 10% of road suspension loss due to road closure disaster

Table 4.5.5 shows benefit of Road Early Information System. Benefit is 11 million Rs/year and it is sufficiently bigger than cost.

Table 4.5.5 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 activities 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.

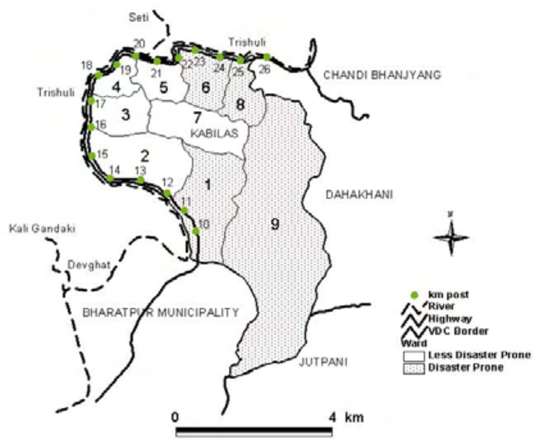


Figure 4.6.1 Locations of Wards in Kabilash Village

4.6.3 Outline of Disaster Mitigation Activities in Kabilash Village

Promotion of disaster mitigation activities in Kabilash Village is planned as below.

(1) Hazard mapping

(2) Disaster education

Educational program on slope disaster shall be made up introduced in the study lessons so that students and villagers knows about the disaster. And education for students and village people shall be carried out once a year before rainy season.

(3) Early Warning/ Evacuation System

Utilizing Road Early Information System, Early Warning/ Evacuation System for evacuation has been formulated as shown in the 4.6.2. Warning criteria is set considering the rainfall intensity analysis and hazard condition of the village.

(4) Simple structural measures

A simple slope protection works for upper slopes of 11km+500 has been implemented as a model case of slope protection works executed by village people.

(5) Forestation planning and countermeasure planning

Plan of planting trees for on slopes was made considering the forest condition of the village.

This plan is implemented in cooperation with through the “Project on Disaster Preparedness and Sustainable Livelihood Development Project, Chitwan District, Nepal” which is jointly implementing by NPO Shaplaneer/ NGO Rural Reconstruction Nepal (hereinafter described as RRN) joint project team starting from September 2007. This project is mainly composed of two major programs that is; a) income generation with finance/saving system and b) disaster mitigation.

First, organization of disaster mitigation activity was formulated as shown in the Figure 4.6.2.

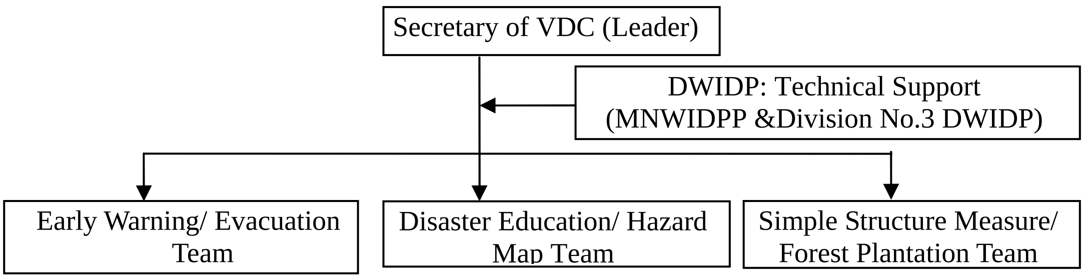


Figure 4.6.2 Organization of Disaster Mitigation Activities in Kabilash Village

Disaster mitigation activity managed by the secretary of the VDC and role of each team are shown in Table 4.6.1.

Table 4.6.1 Role and Activities of Teams for Disaster Management for Kabilash Village

Organization	Role
Kabilash VDC Secretary (Project Chief)	- Act on disaster management generally in Kabilash Village.
VDC Staff	Support VDC Secretary.
Early Warning/ Evacuation Team	- Monitor of raingauges at Kabilash VDC (CH 10km of the N-M highway) - Confirmation of risk level by analyzing of rainfall data - Early warning for villagers
Disaster Education/ Hazard Map Team	- Prepare hazard map with the Study Team, DWIDP, and NGO RRN. - Provide disaster education to school and villagers.
Simple Structural Measure/ Forest Plantation Team	- Conduct/maintain simple structural measure at crossing stream of CH 11km +500 (woks were completed on 16 June 2008) - Plan additional simple structural measure, forest plantation for protect soil erosion and income generation
MNWIDPP and or Division No.3 of DWIDP	Advice/support on disaster management activities to Kabilash Village.

(1) Hazard Mapping

Following two kind of hazard map was made by cooperative work between the Study Team and Disaster Education/ Hazard Map Team.

A) Hazard mapping using satellite image (Quick Bird)

B) Hazard mapping using topographic map

In hazard map following information is shown and utilize for evacuation and disaster education.

Description items of the hazard map

- ➢ Historical Disaster Situation: location, date/time, causality, damaged situation, primary/induced cause etc.
- ➢ Hazard: potential disaster of slopes/ streams/ roads / fallen trees
- ➢ Risky buildings under heavy rain: dwelling houses, tool shed, animal shed etc.
- ➢ Adverse affect slopes: inappropriate land used area (ex. slash-and-burn area), inappropriate water use (ex. great amount leakage irrigation), etc.
- ➢ Expected forestation area: area and preferable plant species (collaboration with NPO Shaplaneer)
- ➢ Evacuation route: Main evacuation route, evacuation sites

- ✧ Utilization of hazard map: hazard map shall be utilized in disaster management under heavy rain fall disaster education for students and villagers.
- ✧ Updating of hazard map: Hazard map shall 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 on hazard map.

(2) Disaster Education

Disaster education for villagers and students shall be carried out continuously once a year before rainy season. Program for education is as below.

A) Program for villagers:

- Review of past disasters and awareness of dangerous area; utilizing hazard map
- Early Warning/ Evacuation System of Kabilash Village
- Site visits

B) Program for students (Class 5)

- Basic knowledge on sediment-related disasters
- Map reading
- Rainfall related with water induced disasters
- Early Warning/ Evacuation System of Kabilash Village

Leaders of Kabilash VDC shall be instructors for education for villagers supported by staffs of DWIDP. And, teachers of each school shall be instructors for students.

(3) Formulation/operation of Early Warning/ Evacuation System

The project set one (1) automatically recording raingauge, and one (1) non-recoding raingauge, and formulate & operate Early Warning/ Evacuation System.

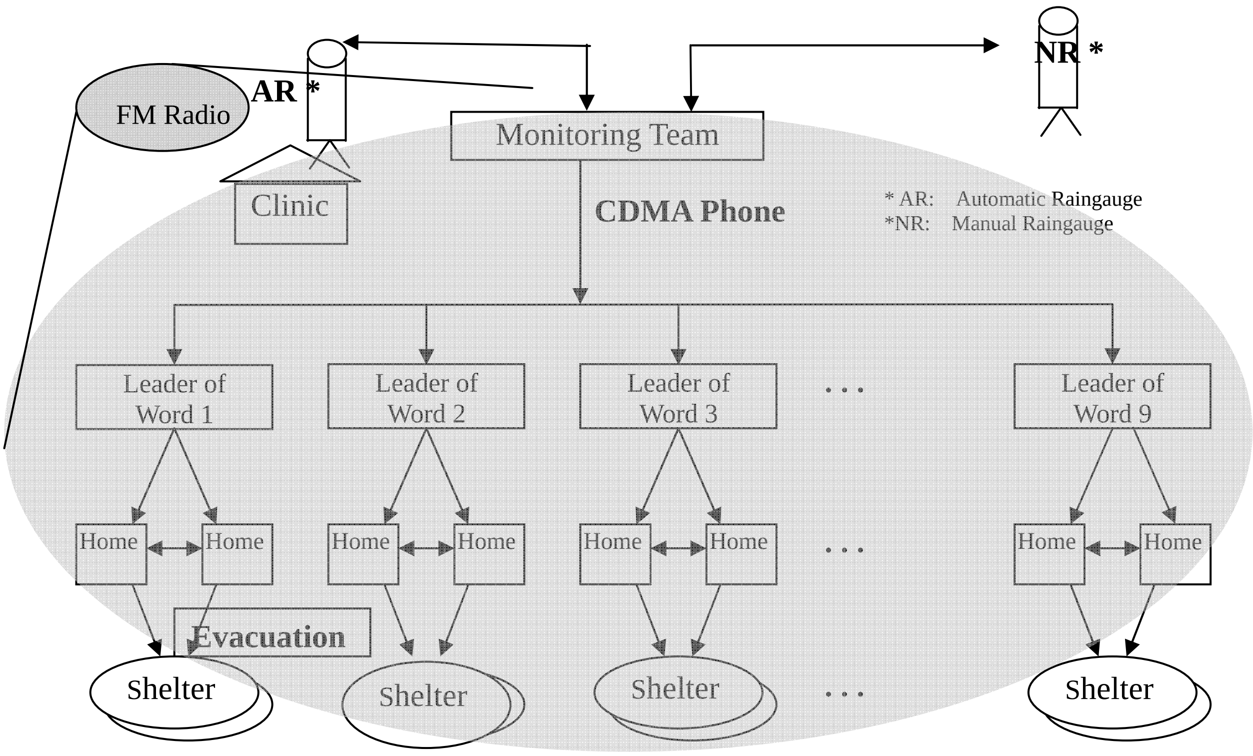


Figure 4.6.3 Information System for Early Warning and Evacuation

To ensure the continuous system operation, the monitoring team maintains the automatically recording raingauges that would set on roof of the clinic, manual (non recording) raingauges, and computer at village office for uploading the raingauge data to internet web-page.

The monitoring team member does the maintenance work by turn of duty. And the duty person should note about weather, rainfall indicator, action, and the other necessary things in a diary.

Table 4.6.2 Threshold of Early Warning by Modified Rainfall Amount

Warning Level	Threshold of rainfall	Action	
		For road User	For inhabitants
Level IV	12 hour half-value rainfall amount = 180mm Ten (10) year return period	**Warning Notice:** Recommendation to avoid traffic on the road	**Warning Notice:** Recommendation to evacuation
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	**Caution Notice:** Recommendation of preparation of evacuation
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	**Set into Preparation** Announce to monitoring members and word/settlement representatives Checking/upload to web-page of modified rainfall amount one hour each

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 4.6.3 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.

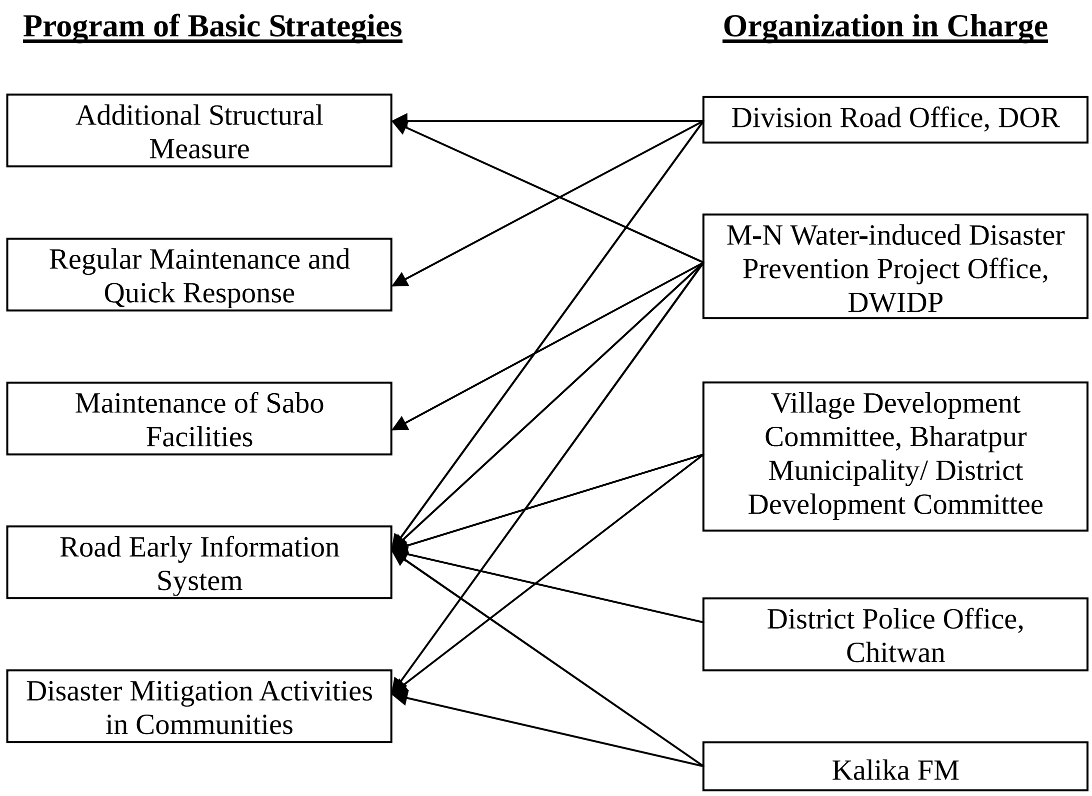


Figure 4.7.1 Implementation Organization for Basic Strategies

Major roles of each concerned organization are as follows.

(1) Division Road Office, Bharatpur, DOR

- To implements structural measures for road slopes.
- Regular maintenance and quick response for traffic blockade induced by sediment-related disasters.
- Monitoring of raingauges and reporting to DPO on risk level of sediment related-disasters on the M-N Highway.
- Maintenance of monitoring devices.

(2) M-N Water-induced Disaster Prevention Project Office, DWIDP

The office implements structural measures for crossing streams, maintenance of sabo facilities, technical support for disaster mitigation activities by communities. DWIDP analyze rainfall data and disaster occurrence, and update rainfall amount criteria for Early Warning/ Evacuation System.

(3) Village Development Committee, Bharatpure Municipality/ District Development Committee

Bharatpure municipality, villages along N-M road offer the account of road traffic obstacles to District Police Office, conduct Early Warning/ Evacuation System and simple slope protection work. District development committee supports the municipality and villages.

(4) Division Police Office Chitwan

Division Police Office Chitwan is the central organization on the Road Early Information System.

- To decide traffic control policy,
- To updates road notice board and internet-web page of Road Early Information System,
- To inform road condition to Kalika FM

(5) Kalika FM

Kalika FM broadcast road conditions informed by DPO and risk level of sediment-related disaster reported by Kabilash Village.

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. The expenditure is shown in Table 4.7.1 to 4.7.4

Table 4.7.1 Necessary Expenditure of Division Road Office, Bharatpure

Program	Item	Quantities	Amount (Rs)	Remark
Additional Structural Measure	Construction Cost	Lump sum	221.600,000	
			Amount per year (Rs/year)	
Regular Maintenance		Lump sum	25,650,000	Annual plan
Quick response	Fuel/ staff cost		392,000	Annual plan
			20,000	Maintenance for equipment, CDMA phone

Table 4.7.2 Necessary Expenditure of MN Water-induced Disaster Prevention Office, DWIDP

Program	Item	Quantities	Amount per year (Rs/year)	Remark
Maintenance of Sabo Facilities	Deposit Removal	Lump sum	1,028,000	

Table 4.7.3 Necessary Expenditure of District Police Office, Chitwan

Program	Item	Quantities	Amount per year (Rs/year)	Remark
Road Early Information System		Lump sum	25,000	Maintenance for equipment, CDMA phone

Table 4.7.4 Necessary Expenditure of Kabilash Village

Program	Item	Quantities	Amount per year (Rs/year)	Remark
Early Warning/ Evacuation System			22,000	Maintenance for equipment, CDMA phone

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.

Evaluated by JICA's guidelines for environmental and social considerations, two social/environmental items are corresponded to Categories C: project is likely to have minimal or little adverse impacts on the environmental and society. There are no items which are categorized into more serious categories. Consideration points of the two items to implement basic strategies are shown in Table 4.8.1.

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 is more than 1 mil. Rs/year) will become less than 1 mil. Rs/year level. 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	It is efficiently 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 can provide more efficient 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	It is required for that prominent risk sites (potential annual loss is more than 1 mil. Rs/year) will become less than 1 mil. Rs/year level. 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	It is efficiently 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 utilized to the ‘IV Road Early Information System’ and it is efficient.

CHAPTER 5

PILOT PROJECT I：ROAD EARLY INFORMATION SYSTEM

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

5.1 Method of Pilot Project I

5.1.1 Purpose of Road Early Information System

The objectives of formulation of Road Early Information System are:

- To formulate an Road Early Information System to save human lives suffered by sediment related disasters,
- To reduce useless traffic suspension by giving early information on adverse traffic condition ahead to drivers. To provide road users information on traffic obstacles for reducing casualties and traffic suspension.

Road information is collect with partnership between public organization and drivers and residents along N-M Highway. This system can be utilized not only for traffic control but also user service by DOR.

5.1.2 Process of Pilot Project

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

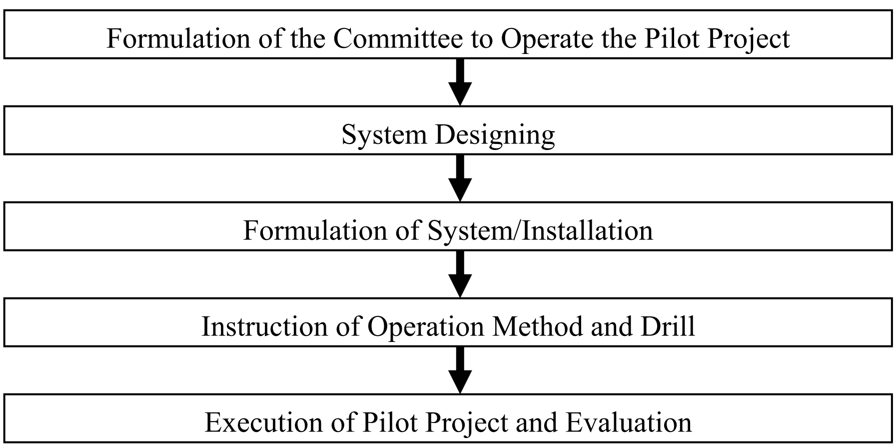


Figure 5.1.1 Process of Execution of Pilot Project

(1) Formulation of the Committee

Planning and management committee has been formulated, because the system is operated with cooperative work among multiple organizations such as Division Road Office. The committee plans and reviews the activities of pilot project.

(2) System Designing

Administrative structure, information network, computer system, and notice board have been designed.

(3) Formulation of System/Installation

Computer system to collect and analyze information has been formulated and raingauges and notice boards have been installed.

(4) Instruction of Operation Method and Drill

A) Instruction for Each Operation Unit

Instruction on operation of system and drill was carried out on 18th June at District Police Office, Chitwan and Division Road Office, Bharatpur

B) Work Shop and Joint Training Exercise

Work shop and joint training among concerned organization was carried out on 26th June in N-M Highway and Kabilash Village

(5) Execution of Pilot Project and Evaluation

After the work shop and joint exercise in 26th June, 2008 mentioned above the pilot project to operate Road Early Information System and Early Warning/ Evacuation System has been carried out by the counterpart and implementing organizations. The performance of the pilot project was evaluated by hearing of drivers and staffs in charge of operation.

5.2 Organization of Pilot Project I

5.2.1 Forming of Committee

The committee for planning and managing the pilot project was formed.

(1) Name of the Committee

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”.

(2) Committee

Two committees were formed as shown in the Figure 5.2.1;

1) Planning and Review Committee (district level) and 2) Advisory Committee (central level). The objectives of these committees for Planning and Review Committee (district level) and Advisory Committee (central level) are to plan/conduct/evaluate pilot projects and to offer useful advice respectively.

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

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

Under these two committees, two implementing organizations have been formulated. That is ; 1) Implementation organization for Road Early Information System and 2) Implementation Organization for Disaster mitigation activities in Kabilash Village.

The roles of members of the committee and implementing organizations are shown in the Table 5.2.1.

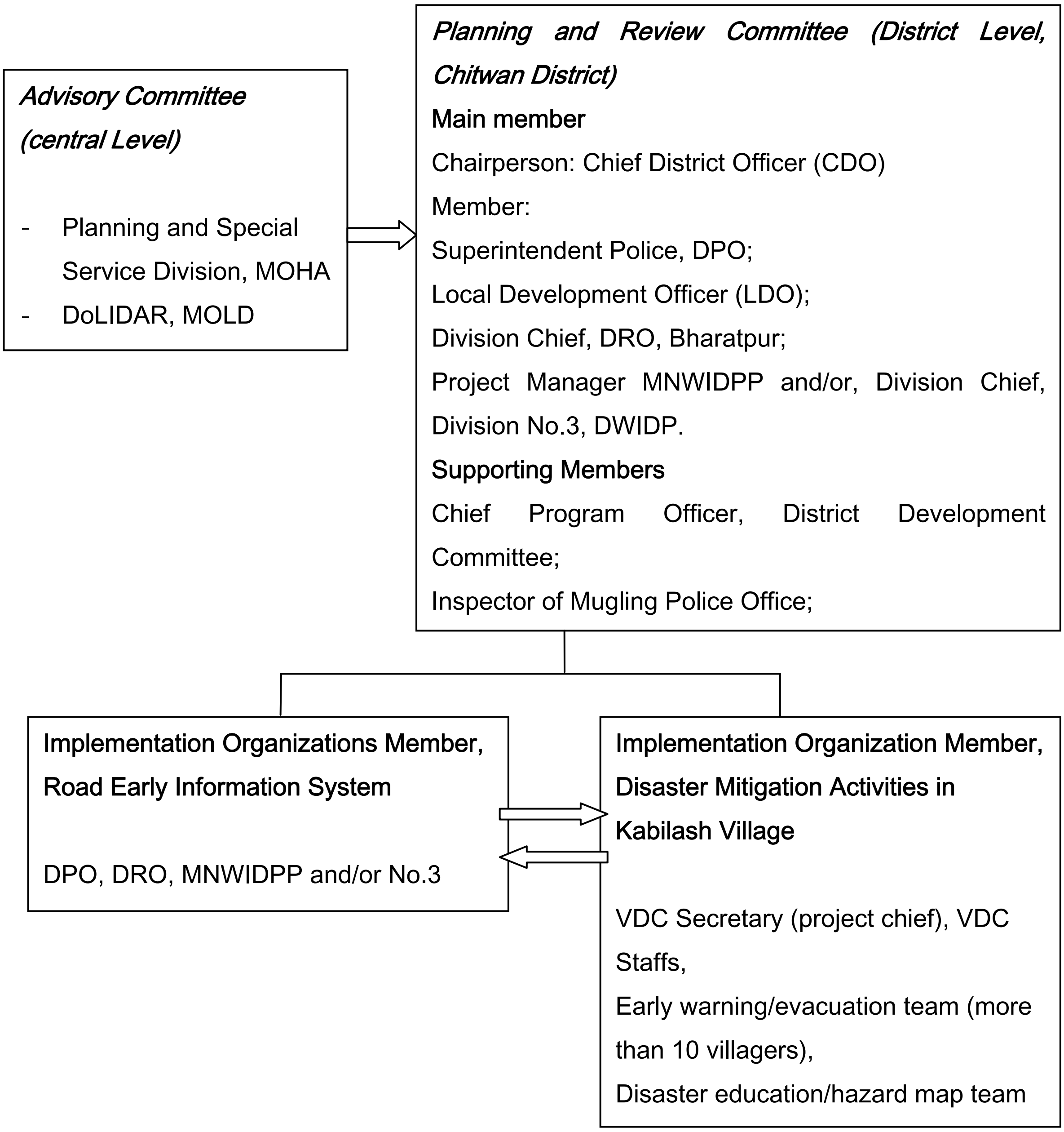


Figure 5.2.1 Committees and Implementation Organizations for Road Early Information System and Disaster Mitigation Activities in Kabilash Village

Table 5.2.1 (1) Committee Members for the Pilot Projects

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

Department of Water Induced Disaster Prevention Ministry of Water Resource (Chairperson of Advisory Committee)	Advice for following water-induce disaster management policy and methodology. - Rainfall monitoring and thresholds setting for Early Warning/ Evacuation System - Hazard mapping, disaster education for Kabilash Village - Simple structural measure at Kabilash Village
Department of Road, Ministry of Physical Planning and Works	Advice of methodology of patrol/report and quick response against road traffic obstacles
Department of Local Infrastructure Development and Agriculture Road, Ministry of Local Development	Advice methodology for implementation of community-based disaster management.

Table 5.2.1(2) 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.

Table 5.2.1(3) Implementation Organization Members for Disaster Mitigation Activities in Kabilash Village

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

5.2.2 System Designing

General system is designed as below.

(1) Installation of Raingauge 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.

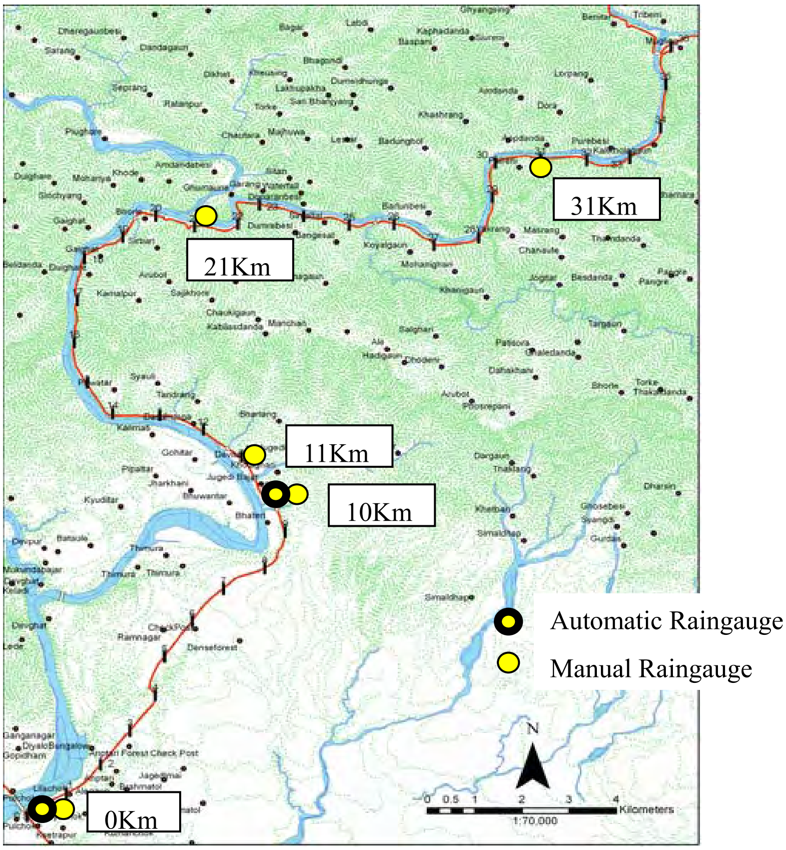


Figure 5.2.2 Location of Raingauge

Automatic raingauges collect hourly rainfall data automatically, and by manual raingauges daily rainfall data are collected which detailed methods are shown in the Table 5.2.2 and 5.2.3.

Schematic illustration of Road Early Information System is shown in the Figure 5.2.3.

Table 5.2.2 Method of Data Collection (Automatic Raingauge)

Item	Description
Frequency	Each hour automatically
Data collected	Hourly rainfall
Location	District Road office：0Km Kabilash VDC：10Km
Collection/ recording method	Automatic raingauges send hourly rainfall to data loggers, which directly connected to computer, by radio connection.

Table 5.2.3 Method of Data Collection (Manual Raingauge)

Item	Description
Frequency	Each day（Morning）
Information corrected	Daily rainfall
Location	Five locations DRO：0 km, 11 km, 21 km, 31km Kabilash VDC: 10 km
Data collection method	Persons responsible to measure manually accumulated water in bottle by measuring cylinder
Recording method	Input in Excel format

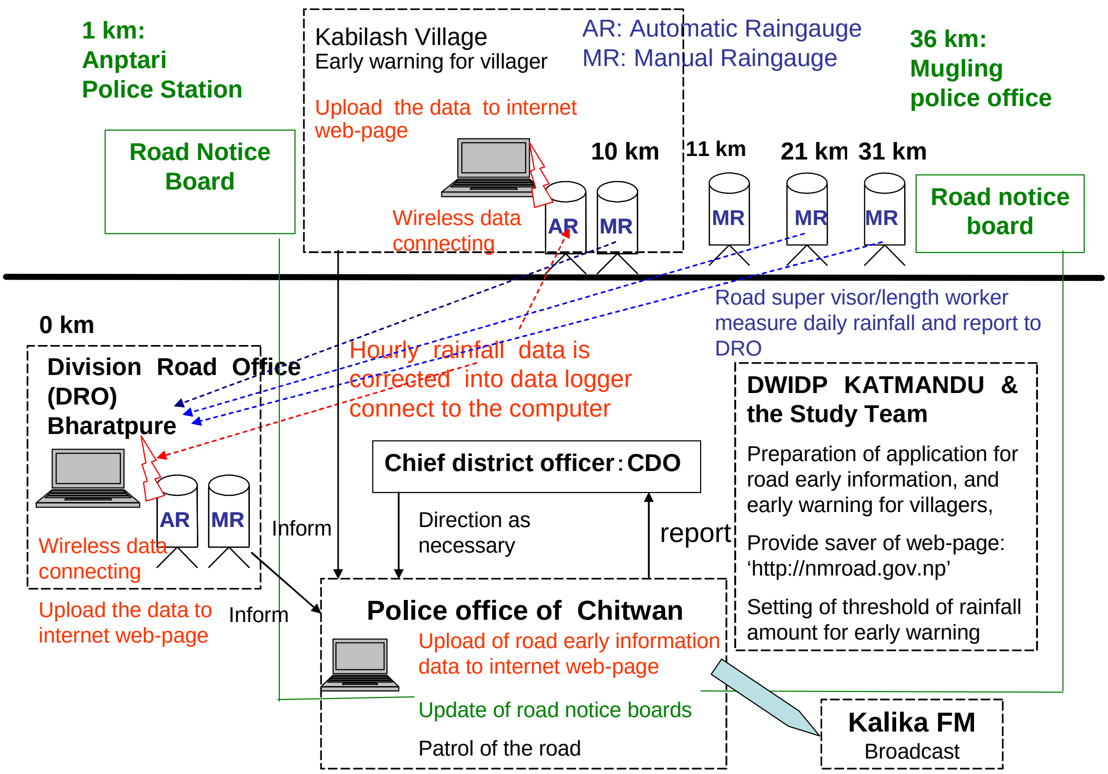


Figure 5.2.3 Schematic Chart of Road Early Information System

(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 5.2.4. Determination of warning level is done by DRO who will report to the DPO for dissemination of warning to drivers.

Table 5.2.4 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) Judgment of Traffic Obstacle

DPO judges the situation of traffic obstacle after confirmation of the fact patrol.

(5) Notice of Rainfall and Traffic Obstacle information

Result of judgment is informed to road users by following three methods.

- Notice board
- Internet Web page; http://nmroad.gov.np
- Broadcast by Kalika FM (95.2Hz)

1） Notice Board

Notice board has been installed at 1km and 36km in N-M Highway.

2）Internet Web Page

Upload for the Web page is carried out by the computer of DPO and information of traffic condition is also informed by DPO to Kalika FM.

(6) Devices of the System

The equipment and the installation location are shown below.

Table 5.2.5 Devices of the System

Devices	Nos	Installed Location	Function/Specification
Automatic raingauge with CDMA phone	2	0Km (DRO) 10Km (Kabilash Village)	Monitoring of hourly rainfall sending monitoring data by CDMA
Computer making content, CDMA, UPS (Access to internet by CDMA)	2	0Km (DRO) 10Km (Kabilash Village)	✓ Program of receiving hourly rainfall ✓ Function of receiving hourly rainfall ✓ Program making graph of 12 hour half –value rainfall amount ✓ Estimation of predicted hourly rainfall ✓ Estimation 12 hour half –value rainfall amount by Excel ✓ JPG image ✓ Judgment of warning level(manual) ✓ Making HTML content(manual) ✓ Home page upload ✓ Data back up function
Computer making content, CDMA, UPS (Access to internet by CDMA）	1	DPO	✓ Information collection(manual) ✓ Making content on traffic obstacle ✓ Upload of home page
Web server	(1)	Partial use of DWIDP Web	✓ Receiving three contents from three computer ✓ Sending to internet
Manual raingauge	4 (1)	0Km (RDO) 10Km (Kabilash Village) 11Km300 existing 18Km, 31Km	✓ Monitoring daily rainfall ✓ Monitoring hourly rainfall under heavy rainfall
Notice board	2	1Km (Anptari) 36Km (Mugling)	✓ Notice of heavy rainfall warning and traffic obstacle

(7) 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 5.2.6 and 5.2.7.

Table 5.2.6 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 10year 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 5.2.7 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

(8) Web page image

Images in the web page are shown in Figure 5.2.4 and information in the image is shown in Table 5.2.8.

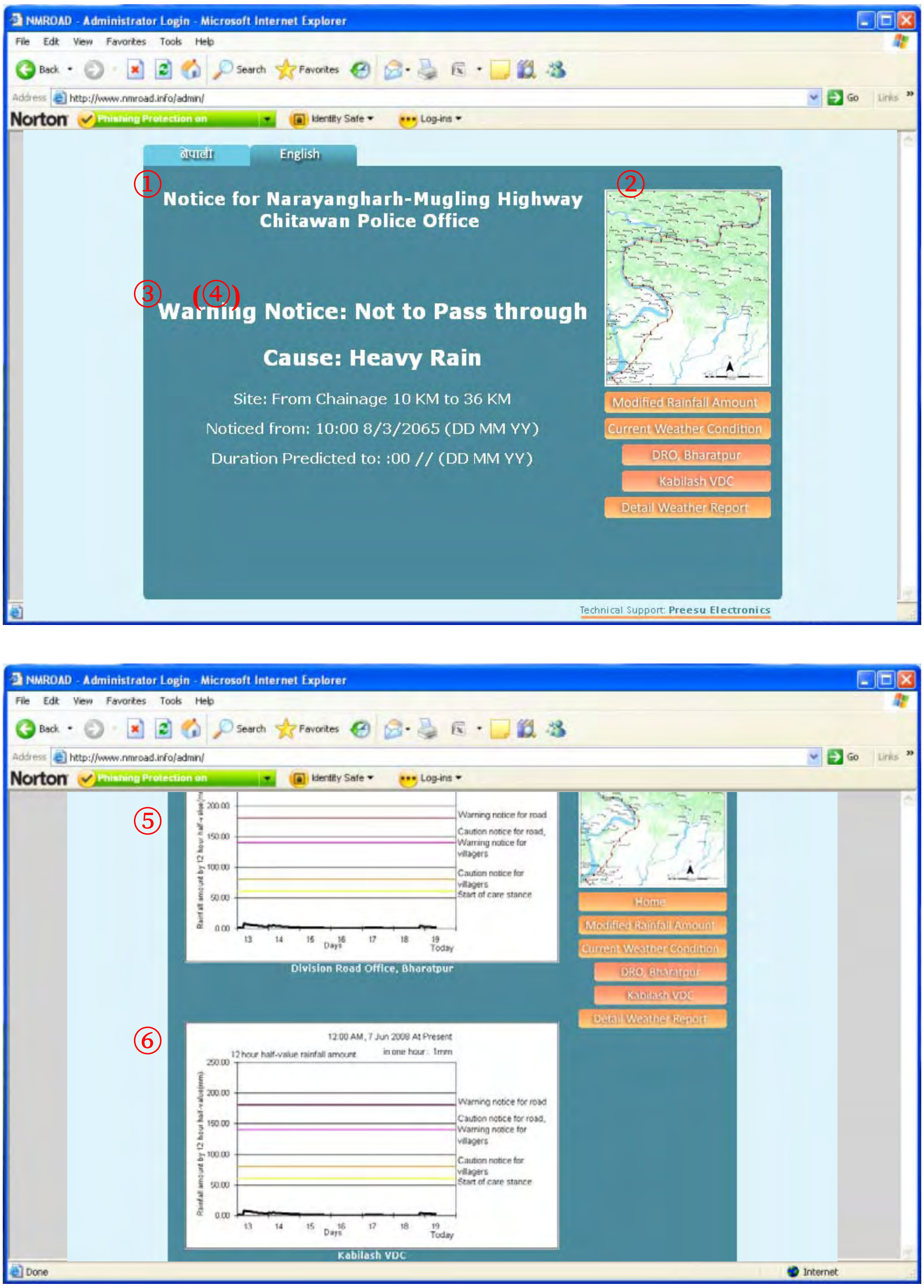


Figure 5.2.4 Web page image

Table 5.2.8 Information in the image

No	Kind	Content
(1)	Title	Name of home page and name of DPO (no upload)
(2)	Location map	Location of N-M Highway (no upload)
(3)	Rain	Warning/caution notice (uploaded by DPO)
(4)	Traffic obstacle	Information on road blockade and congestion (uploaded by DPO)
(5)	Line graph of 12 hour half –value rainfall amount (0 km)	Line graph of 12 hour half –value rainfall amount processed by DRO(uploaded by DRO)
(6)	Line graph of 12 hour half –value rainfall amount (10Km)	Line graph of 12 hour half –value rainfall amount processed by Kabilash VDC (uploaded by Kabilash VDC)

(9) Function of Computer of DRO and Kabilash

1) Program of receiving hourly rainfall

Receiving and display of hourly rainfall from the automatic raingauge.

2) Program of making line graph of 12 hour half –value rainfall amount

(a) Prediction of hourly rainfall

Prediction of hourly rainfall based on latest hourly rainfall. Estimation formula is as below (refer to Chapter2)

$\underline{Rprd = Robs \text{ (mm)}}$

Here

Rprd = hourly rainfall value from some point

Robs = hourly rainfall value until some point

In put current hourly rainfall value by manual and this value is utilize to estimate next 12 hour half –value rainfall amount

(b) Estimation of 12 hour half –value rainfall amount

12 hour half –value rainfall amount is estimated by formula below.

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

Here,

$RA_{Hhv}(t)$ = 12 hour half –value rainfall amount at ‘ t ’

I = ‘ i' hour before t ’ (time)

H = H- hour half –value: term that hourly rainfall reduce to half

H = 12

HR(i) = hourly rainfall value from ‘ i+1 ’ to ‘ i'

12 hour half –value rainfall amount ＝ X168(0.5)168/12＋X167(0.5)167/12・・・＋X1(0.5)1/12＋X0＋X-1

※ Xn: hourly rainfall before n to n+1

※ X0: hourly rainfall until now

※ X-1: predicted hourly rainfall from now to one hour later

(c) Making of Graph

Monitoring data by manual raingauges are accumulated complementarily for analysis of tendency of rainfall pattern of each site.

Graph of rainfall pattern is made based on 12 hour half –value rainfall amount which is saved as Excel file and JPG image file.

Table 5.2.9 Specification of Graph

Item	Specification
Mode of graph	Line graph
Display term (horizontal scale)	One week
Longitudinal scale	0mm - 250mm Display lines below 60mm Yellow (1year return period) 80mm Orange (2 year return period) 140mm Pink (5 year return period) 180mm Red (10 year return period)

(d) Judgment of warning level

The operator judges that the estimated 12 hour half –value rainfall amount is over a threshold or not. When the value shows over a threshold, the operator reports to DPO and requests to notice warning or caution.

(e) Making home page content

Home page content is made up based on graph image and 12 hour half –value rainfall amount (set of HTML file and JPG file).

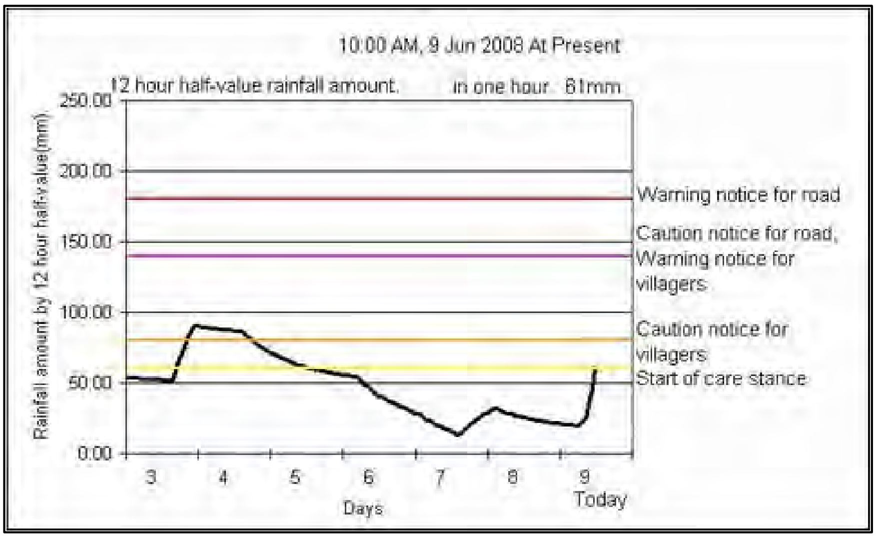


Figure 5.2.5 Graph of Rainfall and Threshold of Warning Level

Image is frame structure and RDO and Kabilash VDC shall upload.

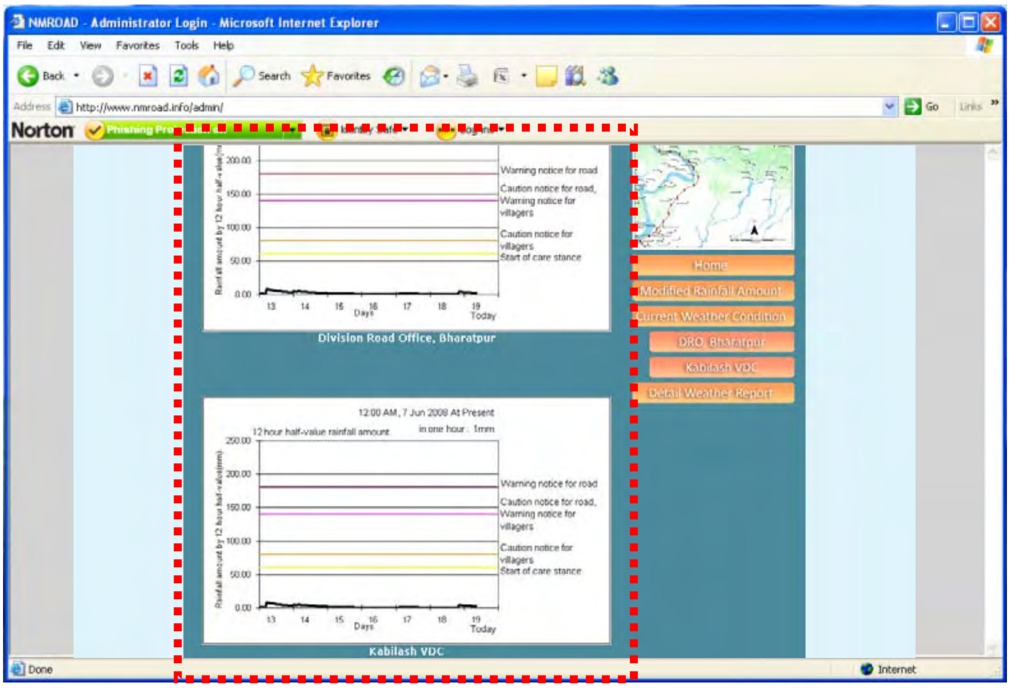


Figure 5.2.6 Image of Display and Graph Layout

(f) Upload of home page

Home page content is uploaded to Web server in internet by manual.

(g) Save of data

All file of 12 hour half –value rainfall amount shall save ten years.

(10) Function of Computer of DPO

1) Making of Web contents

DPO collect information on rainfall and traffic obstacle from various sources shown in the Table 5.2.10 and 5.2.11. Web page content is made up based on patrol

Web page content is shown in the Figure 5.2.7.

Table 5.2.10 Information Collected by DPO

Information	Source
Rainfall data	DRO and Kabilash VDC
Traffic obstacle	Supervisor for road maintenance work, Length worker, Road monitor etc.

2) Display Item on Rainfall

Table 5.2.11 Display Related to Rainfall Information

Item	**Display in Web**
Warning level	・**Warning Notice:** Recommendation to avoid traffic on the road ・**Caution Notice:** Recommendation to careful passage on the road.
Section	From 10Km to 36Km
Date/time	Year/month/day/hour
Situation	・Rainfall reaches 10 year return period ・Rainfall reaches 5 year return period
Graph	Graph of 12 hour half –value rainfall amount (0Km and 10Km) Displayed by line graph (7days)

3) Information of Traffic Obstacle

Table 5.2.12 Information of Traffic Obstacle

Item	**Content of Web**
Situation	・Full lane blockade ・Half lane blockade ・Traffic congestion
Section	From nnKm to mmKm
Date/time	Year/month/date/hour
Reopening	Reopening: Year/month/date/hour
Cause	・Flood/sediment-related disasters ・Traffic accident ・Strike

Figure 5.2.7 Image of Display on Rainfall and Traffic Obstacle Information

Display image which is uploaded by DPO is left side middle as shown in the Figure 5.2.8.

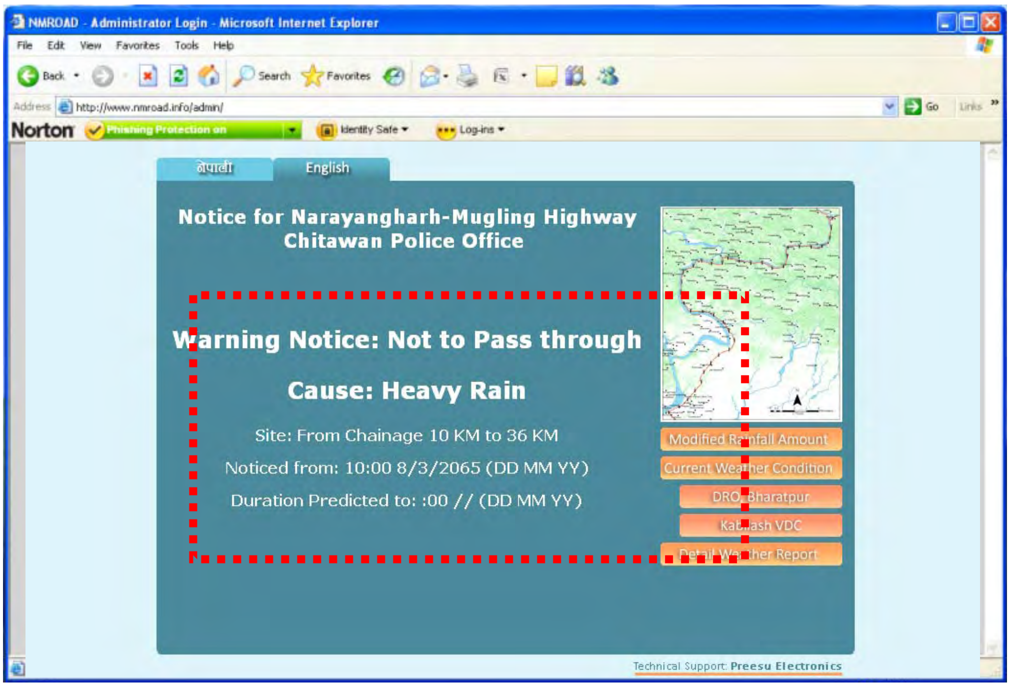


Figure 5.2.8 Image of Display Layout

(11) Installation of Notice Board and Dissemination

1) Location of Notice Board

Manual replacement method is designed for notice boards which is easy to operate and can be maintained successively.

Two notice boards were installed at Anptari (1km) where traffic check station is deployed and Mugling (36km) where is near branch police office of Mugling.

2) Structure of Notice Board and Display

Size of notice board is decided as shown in the Figure 5.2.9 which is considered drivers can read notice item easily.

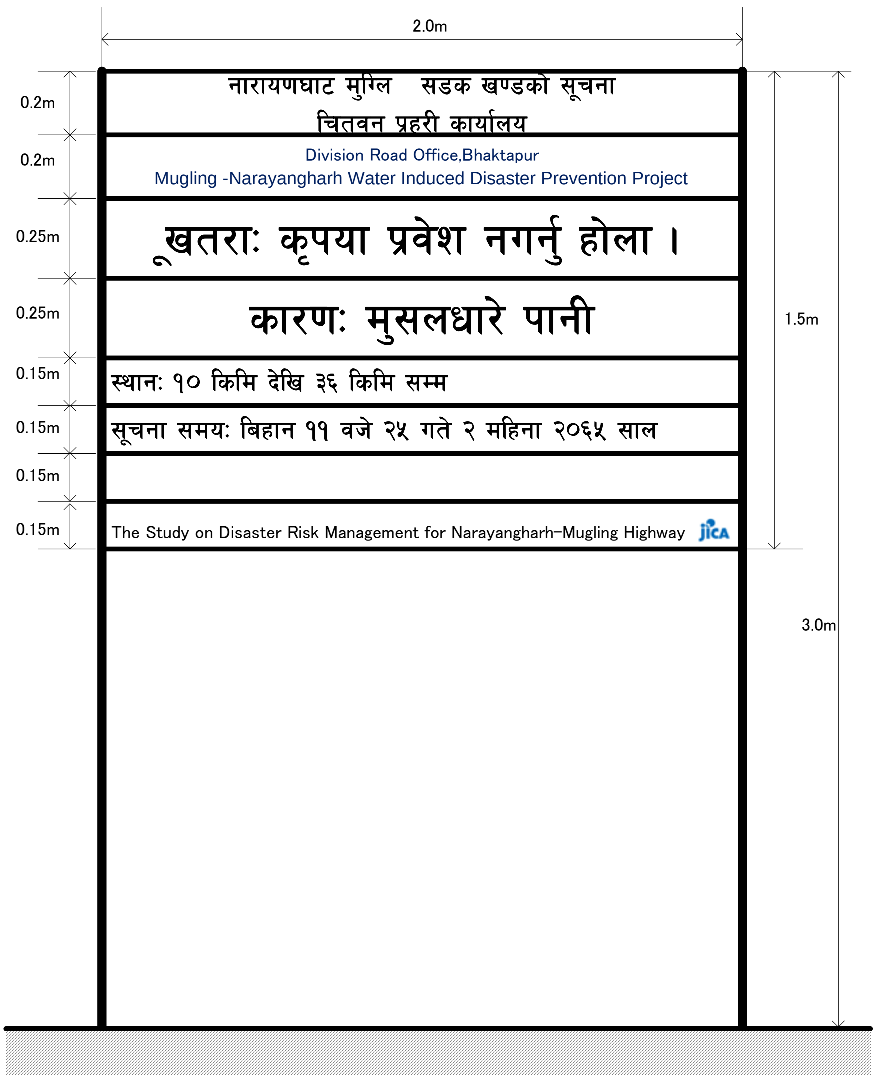


Figure 5.2.9 Dimensional Outline of Notice Board (Rainfall Information)

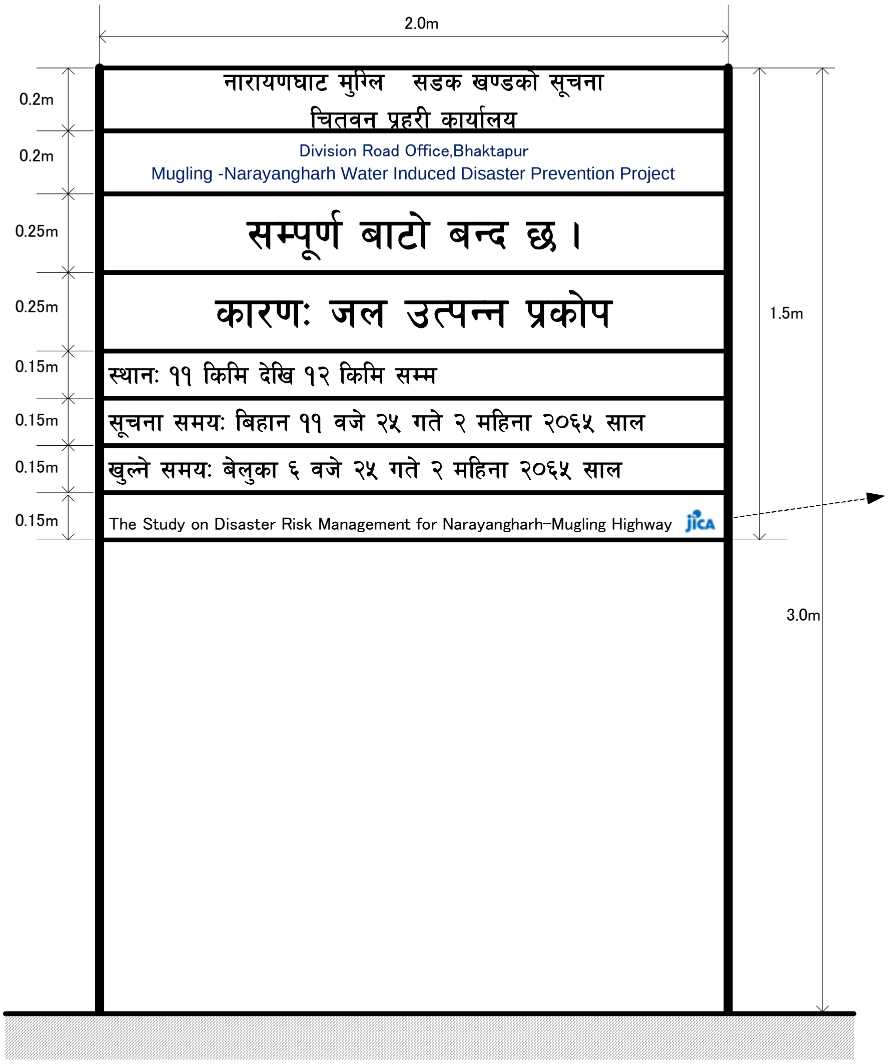


Figure 5.2.10 Dimensional Outline of Notice Board (Traffic Information)

Information in the notice board is the same as internet Web page which is shown in the Figure 5.2.11 and Table 5.2.13.

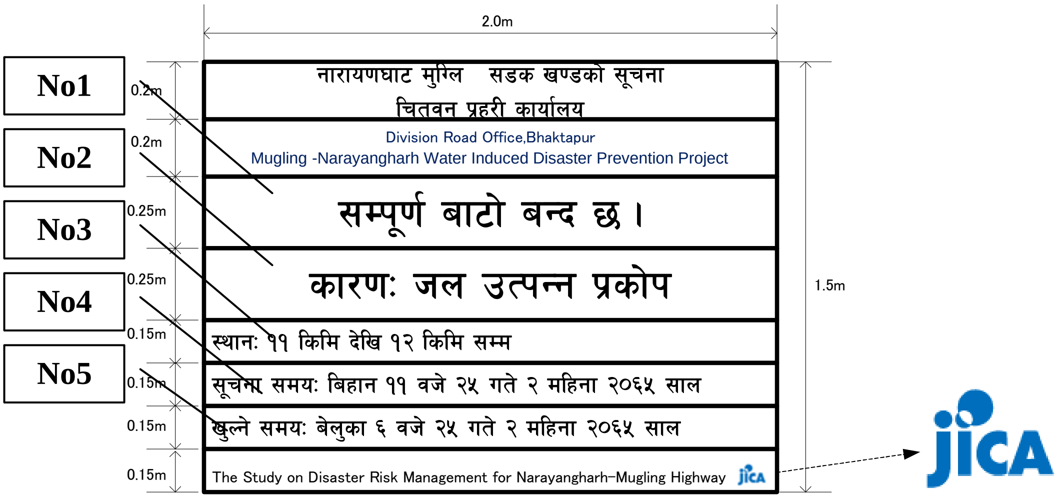


Figure 5.2.11 Display of Notice Board

Table 5.2.13 Information in Notice Board

No	Item	contents
No1	Heavy Rain Information	・ Warning Notice : Not to Pass through ・ Caution Notice : Caution to Pass through
	Traffic Obstacle Information	・ Road Closure of Full Width ・ Road Closure of Partial Width ・ Traffic Jam
No2	Heavy Rain Information	・ Cause：Heavy Rain
	Traffic Obstacle Information	・ Cause：Water-Induced Disaster ・ Cause：Traffic Accident ・ Cause：Strike
No3	Common	・ Site：From Bharatpure/Anptari/Mugling *nn*Km to *mm*Km (Heavy Rain Information is only "From Bharatpure 10Km to 36Km")
No4	Common	・ Noticed from：*hh* AM/PM *dd MMM yyyy*
No5	Heavy Rain Information	・ Blank panel
	Traffic Obstacle Information	・ Duration Predicted to： *hh* AM/PM *dd MMM yyyy*

nn,mm：:0～36
hh：1～12
dd：1～30
MMM： Jan,Feb,Mar,Apr, May,Jun,Jul,Aug,Sep,Oct,Nov, Dec
yyyy：2008～2999

Selection from three

(12) General Image of Road Early Information System

General image of the system is shown below.

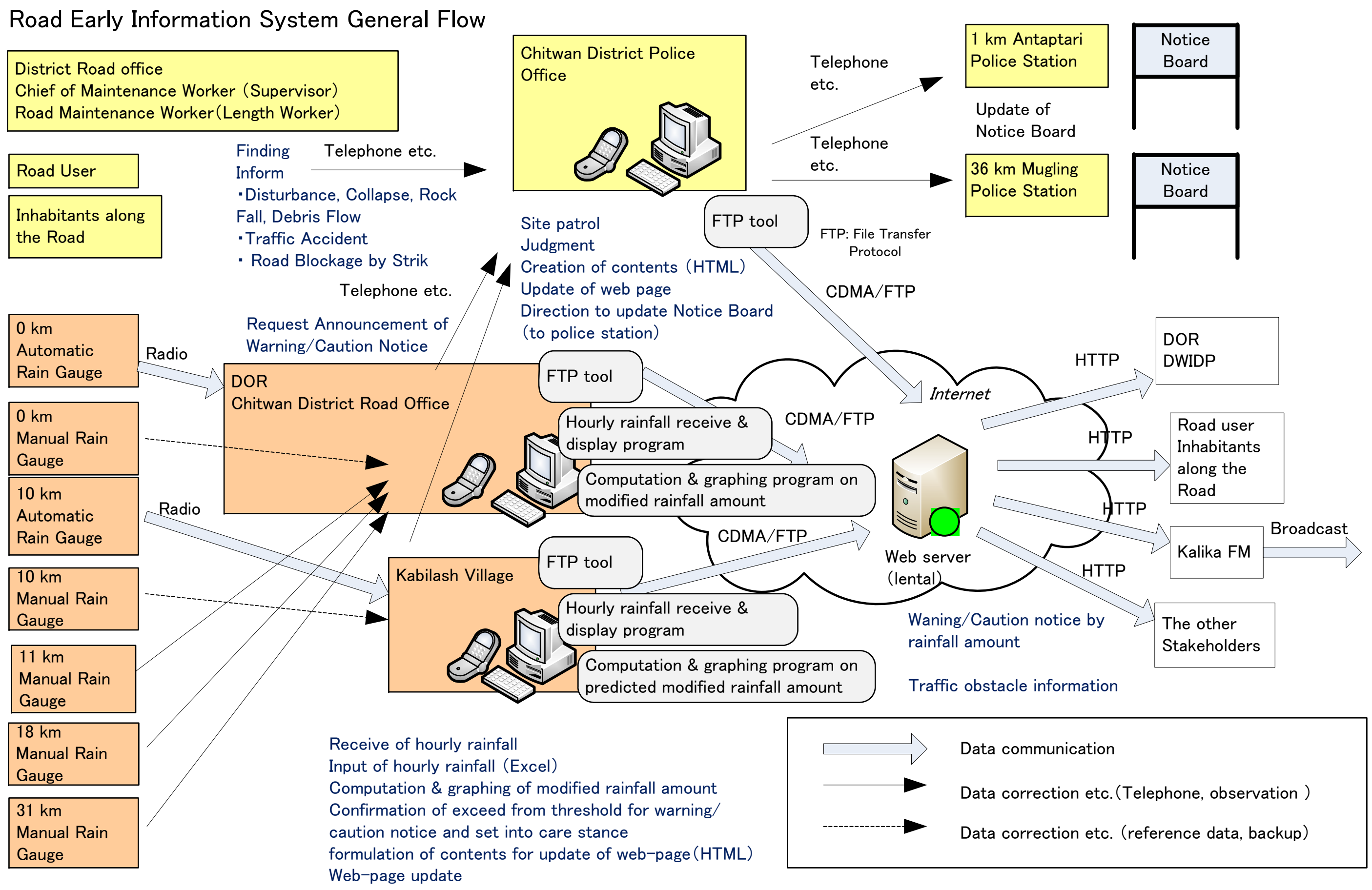


Figure 5.2.12 General Flow of Road Early Information System

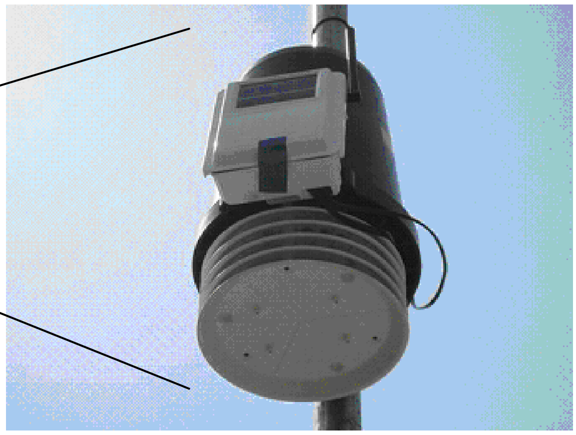
5.2.3 Installation of Devices

Required devices and instrument were installed based on system designing.

(1) Notice Board

1km Anptari Traffic Check Point **36km Mugling near the Branch Police Office**

(2) Automatic raingauge and radio communication part



0km Division Road office

10km Kabilash VDC

(3) Manual raingauge

0km Division Road office

10km Kabilash VDC

21km

31km Chandibanjyang village

(4) Computer (CDMA, UPS)

Near 0km; District Police Office

0km Division Road office

0km Division Road office

10km Kabilash VDC

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 onSystem Operation for

1) DPO

Place : District Police Office Chitwan

Date : 18th June 2008

Participant : Staff of DPO, Traffic police of Anptari, Police of Mugling Branch Office

Instruction : Receiving and arrangement of rainfall and traffic obstacles, making Web page content/uploading, update of notice board.

2) DRO Bharatpur, Chitwan

Place : Division Road office

Date : 18th June 2008

Participant : Engineers of DRO

Instruction : Confirmation of rainfall information, prediction of hourly rainfall based on 12 hour half –value rainfall amount/program. Making graph, making Web page content and method of upload.

3) Kabilash VDC

Place : Office of Kabilash VDC

Date : 19th June 2008

Participant : Staffs of VDC, School teacher

Instruction : Confirmation of rainfall information, prediction of hourly rainfall based on 12 hour half –value rainfall amount/program. Making graph, making Web page content and method of upload.

(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)

Place : Royal Century Hotel, N-M highway and Kabilash Village

Date : 26th June 2008

Participant : Planning and Review Committee member, staffs of DPO, staffs of DRO, staffs of Kabilash VDC and villagers, C/P, the Study Team

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

1) Organization of Drill

Organization of drill was formulated as shown Figure 5.2.13 and roles were given to each operation unit as shown in Table 5.2.14 which is almost same of actual operation of the system.

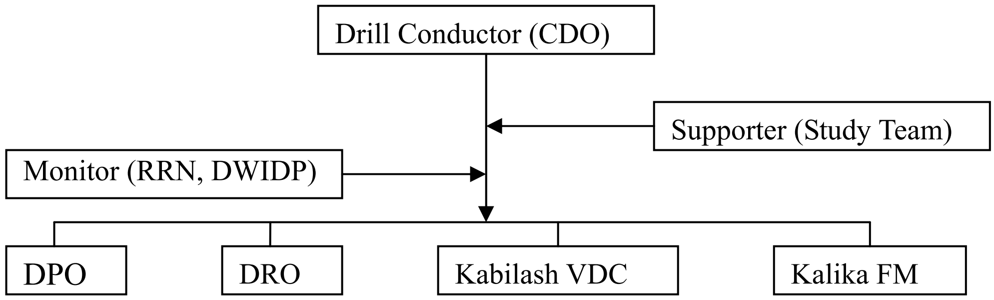


Figure 5.2.13 General Organization of Drill Work

Table 5.2.14 The role for each organization on Drill on June 26th

Organization	Role	Implementation Group	Supporter
District Police office(DPO)	1. Collect urgent information for road traffic obstacles. 2. Patrol/Inspection/judgment about road traffic obstacles. 3. Update information for notice boards. 4. Disseminate information by internet web-page. 5. Urgent response to road traffic obstacles.	- Information Receiver - Decision maker - Computer operator - Board updater - Patrol	The Study Team (Computer operator) RRN (Hearing for road user)
Divisional Road office (DRO)	1. Monitor automatic raingauge and manual raingauge at DRO office. 2. Report road traffic obstacles to police office/station. 3. Patrol/Inspection/judgment about road traffic obstacles for road user. 4. Urgent response to the road disaster.	- Computer operator - Decision maker - liaison - Patrol - Data collector	The Study Team (Computer operator)
Kabilash VDC	1. Monitoring of automatic raingauge and manual raingauge at Kabilash VDC. 2. Report road traffic obstacles to police office/station. 3. Patrol/Inspection/judgment about road traffic obstacles for inhabitants. 4. Urgent response to the road disaster.	- Disaster Education/Hazard Map Team	MNDWIDPP (Information provider) The Study Team (Computer operator) RRN (Hearing for inhabitants)
Supervisor / Length worker	1. Report road traffic obstacles to police office/station	- Finder	
Inhabitants / Road user	1. Report road traffic obstacles to police office/station	- Finder	
Media Association (Kalika FM)	1. Broadcast information of traffic obstacles/ early warming under heavy rain by radio.	- confirmer for Web site	

2) Result of Drill

A Scenario of Disaster Occurrence at 21km+200 was set as below and drill for early warning and evacuation was carried out.

- 10:45: Level 1(12 hour half- value rainfall amount 60mm)
- 11:00: Level 2 (12 hour half- value rainfall amount 80mm)
- 11:30: Level 3(12 hour half- value rainfall amount 140mm)
- 12:30: Level 4(12 hour half- value rainfall amount 180mm)
- 13:00: Level 3(12 hour half- value rainfall amount 140mm)
- 14:00: Level 1(12 hour half- value rainfall amount 60mm)

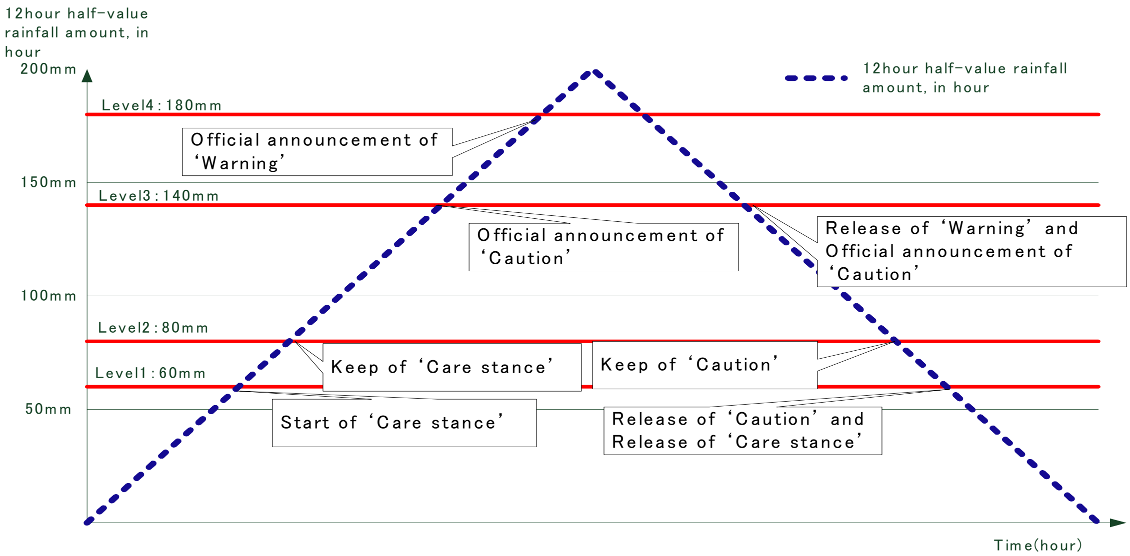


Figure 5.2.14 Scenario of Drill

Drill started 10:30 am and finished 3:30 pm successfully as a drill. Result of drill and findings of improvement for actual operation were as follows.

- **Devices and computer system**: Software for analyzing rainfall data had been installed in the three computers and web site in the DWIDP had been prepared (http://nmroad.gov.np). So, virtual rainfall pattern shown in Figure 5.2.14 could be installed which was the scenario for the drill. But, installation of notice boards is on the way because of delay of aluminizing of steel-frame for the notice board which cased by shortage of power at that time.

  Function of computer system had been verified by test run in the drill. It was found that it was necessary to set antenna for Kabilash Village computer because of instability electric waves to access to the web site in the area.

- **Operation skill of each unit:** Staffs of DOR, DPO, and Kabilash Village operated computers properly.

- **Information network:** It was confirmed that the information network between major operation units: DPO-DRO- Kabilash Village- Kalika FM. But, it was found that reporting from the disaster site was very difficult because telephone was not available from 21km+200 to 10km (Kabilash Village). So, I took around thirty minutes by car for reporting of disaster occurrence for each operation units.

- **Performance of villagers**: Drill of Kabilash Village was focus mainly on operation of the Early Warning/ Evacuation System. Ward 1, 5, 6 was selected for the drill where is many critical places under heavy rain. Operation of computer and information network between village office and leaders of wards was carried out smoothly. But, getting weather information through Kalika FM was difficult because the broadcast on the weather information could not hear in 95.2 MHz. But, later it was found weather information could hear frequency 148.8. Process of Kabilash Village is summarized in Table 5.2.15.

Table 5.2.15 Process of Drill in Kabilash Village

Time	Staffs in Charge	Performance/Remarks
11:00	VDC Secretary /Staffs	Input 89 mm rainfall(Level II), Announce of Recommendation for preparation for evacuation. Upload to The web site was not available due to instability of radio wave.
11:15	VDC Staffs	Report to DPO and Kalika FM; At first, phone line of DPO was very busy to access. But soon later, special line able to access was found.
11:20	VDC Staffs	Confirmation of broadcast on weather information by Kalika FM; At first, Kalika FM cannot hear in 95.2MHz
12:00	VDC Secretary /Staffs	Input 148 mm rainfall (Level III), Announce of order for evacuation to ward leaders.
12:10	Villager	Report to DPO and Kalika FM on evacuation order
12:20	VDC Staffs	Confirmation of broadcast on weather information by Kalika FM;
12:30	Villagers	Villagers began to move to evacuation area
13:00	VDC Secretary /Staffs	Input 176 mm rainfall (Level IV), Kept on evacuation place.
14:00	VDC Secretary /Staffs	Input 123 mm rainfall (Level IV); Release of evacuation order..
14:10	VDC Staffs	Report to DPO and Kalika FM
14:20	Villagers	Villagers left evacuation place to their home.
14:30	Drill was concluded	

- **Review and Discussion on the Drill:** After closing the drill at 2:30 pm, the drill performance was reviewed and evaluated by Mr. H.Bhurtel Engineer, Road Office Bharatpur, Ms. Saraswoti Adhikari; Coordinator, Kabilash VDC and by Mr. Prakash Malla, District Police Office, Chitwan.

Drill was conducted as scheduled and all participants did their role in charge and understood relationship between each operation unit through the drill. Following item was pointed out and proposed for actual operation of the system.

- Broadcast from Kalika FM was very important to notice on critical condition widely. But, relationship between operation units and Kalika FM was not so smooth. Network with Kalika FM should be strengthened.
- Electric wave around Kabilash Village is not stable. Installation of antenna is required to upload to the web site.
- System was conducted suitably, but more training is necessary to operate the system steadily for the pilot projects
- It is necessary to prepare incentive for sustainable system operation. (DPO/Kabilash Village)