Disaster Management Plan (Draft)

Project Number: 49086-001
March 2018

NEP: Upper Trishuli 1 Hydropower Project

Prepared by HECT Consultancy

DISASTER MANAGEMENT PLAN

UPPER TRISHULI (UT-1) HYDROPOWER PROJECT (216 MW)

RASUWA DISTRICT, NEPAL

Prepared by:

HECT Consultancy
Dhumbarahi Height, Kathmandu, Nepal

December 22, 2017

ABBREVIATIONS AND ACRONYMS

ADB	Asian Development Bank
CBDRM	Community Based Disaster Risk Management
CBO	Community Based Organization
CBS	Central Bureau of Statistics
CDO	Chief District Officer
CDMA	Code Division Multiple Access
DAO	District Administration Office
DCP	Data Collection Platform
DDC	District Development Committee
DEM	Digital Elevation Model
DHM	Department of Hydrology and Meteorology
DM	Disaster Management
DDMC	District Disaster Management Committee
DoED	Department of Electricity Development
DMC	Disaster Management Committee
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
EIA	Environmental Impact Assessment
EOC	Emergency Operation Center
EWS	Early Warning System
FGD	Focus Group Discussion
GLOF	Glacial Lake Outburst Floods
G&D	Gauge and Discharge
GoN	Government of Nepal
GPS	Global Positioning System
GPRS	General Packet Radio Service
GRC	Grievance Redressal Committee
GSM	Global System for Mobile
HH	Household
HEP	Hydro Electricity Project
HFL	High Flood Level
HS	Hydrological Station
ICIMOD	International Centre for Integrated Mountain Development
IEC	Information Education and Communication
IEE	Initial Environmental Examination
IFC	International Finance Corporation
I/NGO	International/National Non-Governmental Organization
KII	Key Informant Interview
LALRP	Land acquisition & Livelihood Restoration plan
LBSP	Local Benefit Sharing Plan
LNP	Langtang National Park
MoAD	Ministry of Agricultural Development

MoHA	Ministry of Home Affairs
MoPE	Ministry of Population and Environment
MW	Mega Watt
NEA	Nepal Electricity Authority
NSDRM	National Strategy for Disaster Risk Management
NPR	Nepali Rupees
NRCS	Nepal Red Cross Society
NWEDC	Nepal Water and Energy Development Company Pvt. Ltd.
O&M	Operation and Maintenance
PAF	Project Affected Family
PAP	Project Affected Persons
PCVA	Participatory Capacity Vulnerability Analysis
PDA	Project Development Agreement
PRA	Participatory Rural Appraisal
QRT	Quick Response Team
RAP	Resettlement Action Plan
RF	Rainfall Station
R&R	Resettlement and Rehabilitation
SDI	Serial Data Communication
SMS	Short Message Service
SIA	Social impact Assessment
SOP	Standard Operating Procedures
UHF	Ultra High Frequency
UNISDR	United Nations International Strategy for Disaster Reduction
UT-1	Upper Trishuli-1
VDC	Village Development Committee
V2R	Vulnerability to Resilience
VHF	Very High Frequency
VRLA	Valve Regulated Lead Acid
WB	World Bank

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The Upper Trishuli (UT-1) Hydropower Project is a 216-MW green field run-off-river hydropower facility to be located in the upper part of the Trishuli watershed in Rasuwa District of Central Nepal, 80 km north-east of Kathmandu. As part of the Project Development Agreement (PDA) signed between the Government of Nepal and Nepal Water and Energy Development Company (NWEDC), it is required to prepare the Disaster Management Plan to maximize positive impacts, manage and mitigate the negative outcomes of the project to the extent possible. The preparation of the Disaster Management Plan (DMP) is based on holistic in approach, recognizing that environmental risks arise from the complex interaction of environmental hazards and socio-economic vulnerability.

The main objective of the Disaster Management Plan is met from the following specific objectives:

- Prevention of disasters and their impact on families, infrastructure and environment
- Building resilience of families and communities by reducing their vulnerability and increasing their ability to withstand and minimize the effects of disasters and complex emergencies by enhancing preparedness
- Providing fast, coordinated, effective and appropriate responses to disasters and complex emergencies
- Ensuring timely recovery from disasters and complex emergencies, and leaving communities and families in a better position to withstand future hazards

The plan is divided into seven chapters. Chapters 3 and 4 deals on the issues related to dam break/inundation analysis and installation of early warning systems at two strategically vulnerable downstream areas. The study has compared possible failure scenarios with flooding associated with natural weather events and the operational carrying capacity of the dam. The dam break analysis, conducted through HEC-RAS modeling, has identified remote possibility of concrete dam failure in the proposed UT-1 HEP, which is being built with highest technical standards and adequate quality control. Hence, it can be reiterated that there is no possibility of dam failure of Upper Trishuli-1 HEP. Similarly, the inundation map analysis and water level discharge data reveals that disaster is less likely to impact downstream population as human settlements are well above 20 meters from flooding level in critical areas. However, considering the fragile geology of the river system, it recommends to maintain a high alert for downstream vulnerable areas after the flood water reaches Pahirobesi.

As the DM Plan is a joint initiative of the Government of Nepal and NWEDC, it has given due consideration to mobilize the existing strengths of the district administration for disaster preparedness and response measures. Similarly, the plan also identifies developing system architecture for the installation of two early warning systems at the powerhouse in Mailung Bazar and Betrawati in downstream area.

The Disaster Management Plan proposes to allocate financial resources amounting to NPR 1,13,89,100 *(Rupees one crore thirteen lakh eighty-nine thousand one hundred only)* for its implementation.

Chapter 1: Introduction to the Disaster Management Plan

1.1 Contextualizing Disaster Management Plan

Disaster is an unwarranted, untoward and emergent situation that culminates into heavy toll of life and property and is a calamity sometimes caused by "force majeure" and also by human error. Identification of all types of disaster involves critical review of the ground reality and study of historical past incidents/ disasters in similar situations. The evolution of Disaster Management Plan (DMP) deals with various aspects such as provision of evacuation paths, setting up of alarms and warning systems, establishing communicating system besides delineating an emergency response with an effective response mechanism. Keeping in view the grievous effects disaster can cause on people, loss of property and environment, it becomes necessity to assess the possibility of such failures and accordingly formulate contingency plans.

UNISDR (2009) defines disaster as "a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources." UNISDR defines disaster risk management as the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

A definition for the term 'disaster management' is not included in the UNISDR's handbook of terminology. However, the proposed, but not yet adopted, "Updated Terminology on Disaster Risk Reduction" of UNISDR has proposed the following definition for the term Disaster Management (UNISDR 2015): The organization, planning and application of measures preparing for, responding to and, initial recovery from disasters." As per this definition, disaster management focuses on creating and implementing preparedness and other plans to decrease the impact of disasters and build back better. Failure to create/apply a plan could result in damage to life, assets and lost revenue. However, it may not completely avert or eliminate the threats.

Nepal faces a wrath of natural and human-induced disasters with greater frequency and intensity. Due to its geographical and other climatological conditions, rugged and steep topography, extreme weather events and fragile geological conditions, the country is regarded as a disaster hotspot because of the vulnerability of population together with regular and frequent occurrence of natural hazards. The country's social context characterizes with low level of development as well as low level of institutional capacity consequent to intensify the impact of disasters (Nepal Disaster Report, 2009).

Therefore, it is a great challenge to protect infrastructure and property from frequent disasters such as landslides, floods and fire. Each year, flood, landslide, fire, epidemics, avalanche and various other natural and human-induced disasters lead to the casualty of thousands of human lives and destruction of physical property worth billions of rupees. The earthquakes of 1934, 1980, 1988, 2015 and the flood of July 1993, 2008 and 2014 are the most devastating disasters which not only caused heavy losses of human lives and physical property but also adversely affected the development process of the country as a whole.

The most common natural disasters in Nepal are, landslides, debris flow, floods, earthquake, snow avalanche, Glacial Lake Outburst Floods (GLOFs), hailstorm, thunderbolt, heat and cold waves and epidemics. A significant proportion of the Gross Domestic Product (GDP) is lost every year due to natural disasters. The poor, marginalized and disadvantaged groups of people are hardest hit by natural calamities that occur in the country. The reason for high number of loss of life and property in Nepal may be attributed to inadequate public awareness, lack or inadequacy in preparedness, weak governance practices, ineffective coordination among inter-governmental agencies, inadequate financial resources, and lower level of technical knowledge and skill in the mitigation of natural disasters (Upreti, 2008).

Being an under-developed country, Nepal lacks strong mechanism to widely share knowledge and information to vulnerable communities. More importantly, the vulnerable communities and poor people have not been able to mitigate, prepare for, effectively respond and overcome the impact of multiple hazards in various parts of the country. Often women, children, elderly and disadvantaged persons become unable to cope with disasters as their capability and resilience is meagre. Therefore, it is highly necessary to build the capacity of the vulnerable communities in order to reduce the loss of human lives and physical property during disasters.

According to the Ministry of Home Affairs (MoHA), since 2000, an average of 329 people have lost their lives every single year due to various disasters and property loss of more than one billion rupees. The accompanied indirect losses, in terms of lost time and opportunities, and the lack of services may be several times more than the direct economic loss (Nepal Strategy for Disaster Risk Management, 2008). The Ministry has calculated the economic losses due to disaster for the last 23 years (1983–2005) to be over NPR 28 billion. The accompanying indirect losses, in terms of lost time and opportunities, and lack of services and repercussions thereof, may lead to actual loss that would be much higher. The shock of the 2015 Gorkha Earthquake and the catastrophic floods and landslide in Sindhupalchowk district and Far Western Region of Nepal in 2014 calls for the growing realization of the nature and seriousness of multiple hazards in Nepal which demands heavy investment and multi-actor commitment in disaster resilience.

Table 1: Human deaths from disasters in Nepal since 2000 to 2015

Year	Flood/ landslide	Thunderbolt	Fire	Hailstorm	Windstorm	Avalanche	Epidemic	Earthquake	Total
2000	173	28	37	1	2	0	141	0	382
2001	196	36	26	1	1	0	154	1	415
2002	441	6	11	0	3	0	0	0	461
2003	232	62	16	0	20	0	0	0	330
2004	131	10	10	0	0	0	0	0	151
2005	141	18	28	0	0	21	41	0	249
2006	141	15	3	1	0	0	34	0	194
2007	216	40	9	18	1	6	0	0	290
2008	134	16	11	0	2	0	3	0	166
2009	135	7	35	0	0	2	10	0	189
2010	240	70	69	0	2	2	462	0	845
2011	263	95	46	2	6	0	36	0	448
2012	123	119	77	0	18	9	9	6	361
2013	219	146	59	NA	3	7	4	0	438
2014	241	96	62	NA	3	38	12	0	452

2015	129	128	69	0	3	14	14	8980	9337
Total	**3155**	**892**	**568**	**23**	**64**	**99**	**920**	**8987**	**14,708**

Source: Ministry of Home Affairs, 2015

Figure 1: Human deaths by disasters since 2000 to 2015

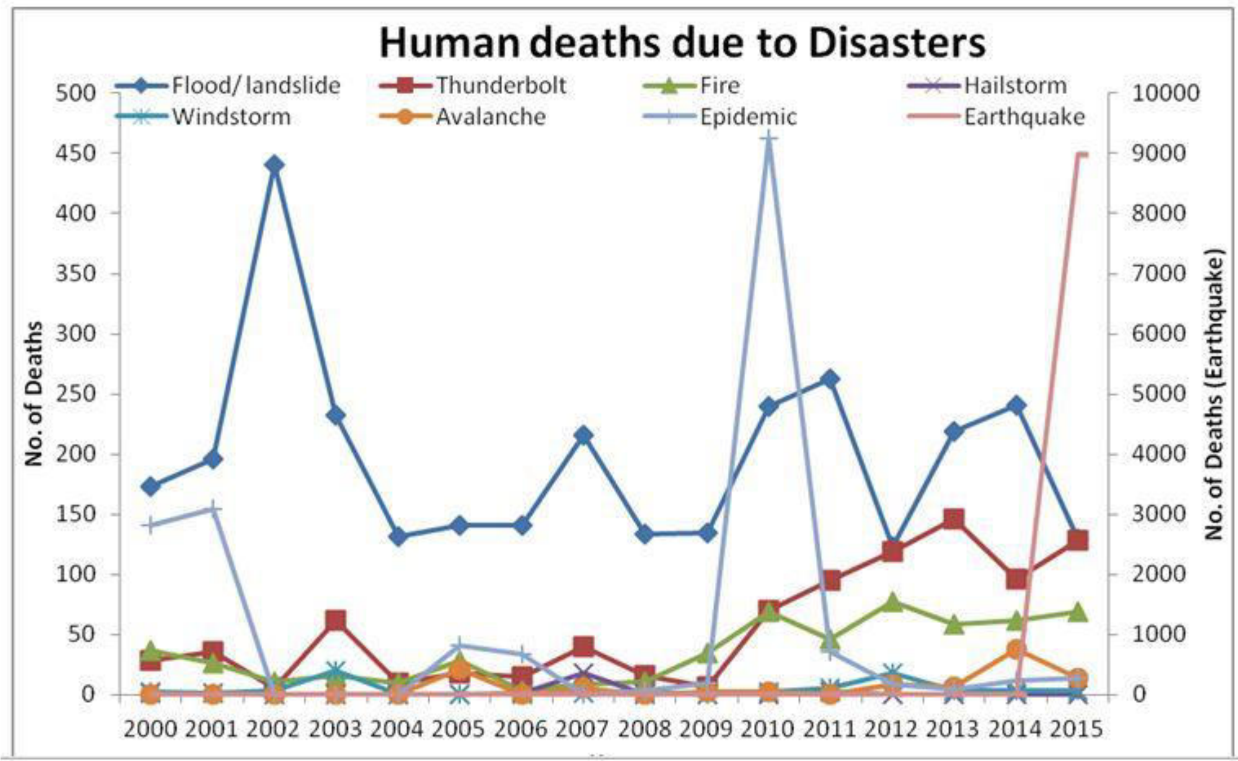


Table 2: Types of natural and human-induced hazards in Nepal

Types of hazards	Prevalence
Natural hazards	
Earthquake	Nepal lies in high-hazard earthquake zone
Flood	*Terai* and Mid Hills
Landslide and landslide dam breaks	Hills and mountains
Debris flow	Hills and mountains; severe is areas of elevations greater than 1700m that are covered by glacial deposits of previous ice age
Glacial Lake Outburst Floods (GLOF)	Origin at the tongue of glaciers in higher Himalayas, higher mountains, flow reach down to middle hill regions
Avalanche	Higher Himalayas
Fire (forest)	Hills and *Terai* (forest belt at the foot of southernmost hills)
Drought	All over the country
Windstorm	All over the country
Hailstorm	Hills
Lightening	All over the country
Human-induced hazards	
Epidemics	*Terai* and Hills; also in lower parts of the mountain region
Fire (settlements)	Mostly in *Terai*; also in Mid-Hill region
Accidents	Urban areas along road network
Industrial/technological hazards	Urban/industrial areas
Soil erosion	Hills
Social disruptions	Follows disaster-affected and politically disturbed areas

Source: Nepal Country Report, 2009

1.2 Brief description of the project

The UT-1 Hydropower project is proposed to be developed as a 216 Mega- watt (MW) green field run-of-the-river project located in the upper part of the Trishuli watershed, in the Haku VDC, Rasuwa District in the Central Development Region of Nepal, approximately 50 km north of Kathmandu. IFC Infra-Ventures has signed a Joint Development Agreement (JDA) with Korea South-East Power Co. Ltd, Daelim Industrial Co., Ltd, Kyeryong Construction Industrial Co. Ltd. and Jade Power Private Limited to develop the project in March 2012. The Project Development Agreement (PDA) with the Government of Nepal was signed on 29th December 2016.

As many as 14 projects are planned along the Upper Trishuli River representing 838 MW of hydropower capacity—a number greater than the total current hydropower capacity of Nepal. UT-1 project is the largest project among these 14 projects in pipeline. Since UT-1 is a run-of-the-river project, the amount of power it generates will be sensitive to changes in the volume and timing of streamflow.

The project's concept is classic, with structures including temporary upstream and downstream cofferdams, diversion tunnels in the right bank, a gravity type concrete weir with three spillway gates, an intake, three underground de-sanding galleries, a long low-pressure tunnel to a surge tank, a vertical shaft to the short high pressure tunnel, a valve chamber, a 216 MW, underground powerhouse containing three vertical axis Francis generating units operating under a gross head of 350-m and associated equipment, a tailrace surge chamber-draft tube gallery and finally a short pressurized tailrace tunnel.

1.3 Project location

The UT-1 Hydropower project is a 216 MW green field runoff-river hydropower facility located in the upper part of the Trishuli watershed, in the Haku VDC, in Rasuwa District in the Central Development Region of Nepal, 50 km north of Kathmandu. The geographical coordinates of the project are longitude (between 85°12′40″E and 85°18′03″E) and latitude (between 28°04′27.50″N and 28°07′42″N). The largest part of the catchment area of the river lies in the Tibet China (60 %) and 9% of them are composed of glacier and snow. 85% of 4,640 km^2 of drainage area are located above El.3,000 m, and 11% of them are located above El.6,000 m. Trishuli river is one of the major river basins in the country. The construction site of UT-1 HEP is located 275 m below the intersection of Bhotekoshi where Dunche and Haku are near Trishuli river's junction.

Access to the powerhouse is by tunnel, with the control building and substation next to powerhouse. The total water conduit length is a little over 10 kilometers. The intake site is located near the confluence of Bhotekoshi river at Dhunche and Haku VDC on the right bank of Trishuli River, about 70km directly north of Kathmandu. The Project consists of a 77 metre-wide diversion dam in a narrow gorge located 275 metres downstream of the confluence of the Trishuli with the Bhotekosi River. The direction of the valley is mostly south-west. The dam site can be viewed on Google Earth at 28-07-36.61N and 85-17-52.42E. Apart from the dam and spillway, all structures are located underground on the right bank of the river. The Pasang-Lhamu highway passes on the left bank of the river, and is the primary access route for the development.

Map 1: Location map Upper Trishuli-1 HEP

1.4 Salient features of Upper Trishuli-1 HEP

The proposed UT-1 HEP is a peaking run-off-river (PRoR) scheme with daily peaking of at least 3.65 hours. The dam site in Trishuli river is in the vicinity of Hakubesi village and the power cavern site is close to the village of Mailung. The UT-1 HEP envisages an installed capacity of 216 MW and is located in Rasuwa District. The location details and salient features of the project are summarized in Table 3 below:

Table 3: Salient features of UT-1 HEP

Location	Rasuwa District, Bagmati Zone (80 km Northwest of Kathmandu) Intake site at Hakubesi of Haku VDC and powerhouse site at Mailung of Haku VDC Latitude: 28º04'27.5"N-28º07'42"N Longitude: 85º12'40" E-85º18'03" E
Catchment and hydrological data	
Catchment area and intake site	4350.88 km²
Area below 3000m elevation intake site	276.9 km²
Area below 5000m elevation intake site	2445.3 km²
Discharge at 90% exceedance	37.14 m³/s
Design discharge	76 m³/s
Design flood (2000 year)	3275.90 m³/s
Project features	
Gross Head	350m
Net Head	333.93m
Installed capacity	216 MW
Average annual energy	1533.06 GWh
Saleable energy	1456.40 GWh/yr
Dry season energy	564.36 GWh/yr
Wet season energy	892.04 GWh/yr
Diversion structure	Weir (100.9m wide)
Intake	Side intake type
Desander	Underground (L=115m, D=23.93m, W=10m, Number of bay is 3)
Desanding flushing	Underground tunnel length= 190m and width 3.14m
Head race tunnel length	About 9.715km, 6.5m circular shape
Surge tank	Circular shape 8.5m diameter and 50m height
Vertical shaft	Length=292m and diameter of shaft= 6.5m
Audit at different location	Length=1135m, D shape diameter 4m
Type of powerhouse	Underground
Size (L*B*H)	90m* 18.7m* 43.9m
Transformer gallery	Underground type
Switchyard & Office area	Underground
Turbine type	Francis Turbine, 3 number each 72 MW

Access Road and Transmission Line	
Access road length	20.30 km road from Mailung Dhovan to intake site including all audit and road to Tungbar access
Transmission line from takeoff yard to transmission tower no. AP27 of Chilime-Trishuli 220 kV line (length-689m)	Connected to 689m length of 220kV single circuit to Upper Trishuli-3B
Construction Period	
Construction period	5 years from start of construction
Total Cost	US$ 475 Mil (Without IDC, Working capital)

(Source: Detail Design Report of UT-1, 2017)

Nepal with its fragile geology, steep slopes, high relief, and variable climates, is prone to water induced disasters such as floods and landslides. 80% of annual precipitation is produced during the short monsoon season being the runoff for many rivers. Generally, the melting of glaciers is a source for perennial rivers and also source for underground water. These glaciers and glacier lake leads a boon for the development of hydroelectric power plant. Trishuli is a perennial river with its source at the Tibetan Himalayas. Not only benefit but also some time there might be losses of life's and property. Over the last three decades, floods and landslides caused around 7000 deaths and more than US $ 300 million in damage of infrastructures.

The climatic conditions in Trishuli River basin are strongly controlled by altitude. Substantial difference is observed with variations in altitude. The climate of the area is monsoonal in nature, as about 70% of the annual precipitation is received in the months from June to September. Since, Trishuli river basin lies within Eastern Himalayan region, where the monsoon has a more extended regime, rainfall is received throughout the year.

1.5 Objective of the Plan

As per the PDA Guideline Note, Schedule 13 (refer Annex 10), following are major objectives of the Disaster Management Plan:

- Mitigation of disasters and their impact on families, infrastructure and environment;
- Building resilience of families and communities by reducing their vulnerability and increasing their ability to withstand and minimize the effects of disasters and complex emergencies by enhancing preparedness;
- Providing fast, coordinated, effective and appropriate responses to disasters and complex emergencies; and
- Ensuring timely recovery from disasters and complex emergencies, and leaving communities and families in a better position to withstand future hazards.

1.6 Rationale of the Plan

Any hydroelectric project if not designed on the sound principles of design after detail investigations in respect of hydrology, geology, seismicity etc., could spell a large-scale calamity. Thus, there are inherent risks to the project like improper investigation, planning, designing and construction, which ultimately lead to human catastrophe.

Hydropower projects involve construction of underground/surface power houses and other surface structures like dams, weirs, barrages and underground structures like head race and trail race tunnels having large diameters and length up to several kilometers in addition to electrical /mechanical equipment as in all other power stations. Some of reasons of disaster is as under:

- Earthquake may affect any part of hydro power station, which needs to be taken care by proper seismic and geological studies during designing;
- Landslide is other major source, wherein main areas affected are water conductor systems, surface power house and diversion structures, etc.;
- Possible failure of a dam and the sudden release of artificially stored water becomes a potential menace to downstream inhabitants; and
- Possible disasters like failure of any underground structure due to geological reasons, fire in cable galleries, switchyard and switchgear rooms, over speeding of turbines, etc.

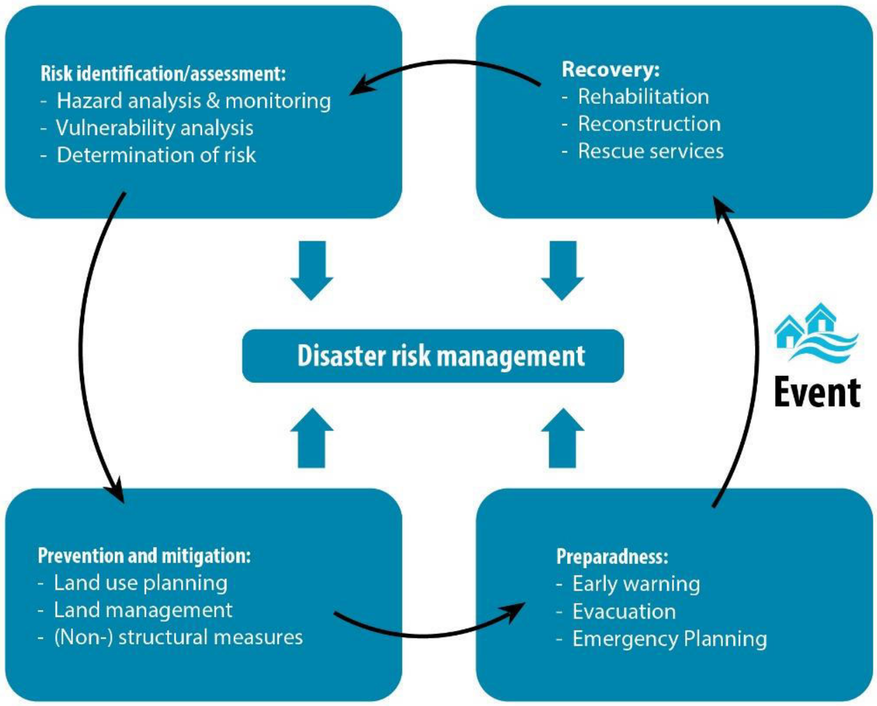
Thus, hydropower stations need special consideration to avoid disasters. The necessity becomes even more relevant from the fact that hydropower projects are generally located in remote or hilly areas. The problem is more serious in case of underground hydro-electric installations getting fire, flooding, etc. Some of the disasters occurred in the hydropower sectors are as under:

Damage due to storm in 1993, an extraordinary 24-hour rainfall event of more than 540 mm with an intensity of about 70 mm/h took place on July 19-20, 1993. As a consequence, slope failures, landslides and debris flows occurred in the catchment. The penstock of the project Kulekhani Hydropower Project, Makwanpur district was completely swept away by debris flow at Jurikhet. Because of the Sindhupalchowk landslide that occurred in August 2014, five hydropower projects were impacted, namely, (i) 2.5MW Sanima, (ii) 10MW Sunkoshi, (iii) 45MW Bhotekoshi, (iv) 6MW Chaku and (v) 3MW Bhairabkunda hydropower projects. Hence, in view of most of the project's structures underground and of large capacity, there is a strong need to formulate the Disaster Management Plan (DMP) for UT-1 HEP.

UT-1 HEP PDA's Schedule 13 Disaster Management Plan Guidance Note and the Rehabilitation and Resettlement Plan are the overall framework documents for the preparation of the plan. The plan identifies potential emergency conditions at the project site during construction and operation stage and specifies pre-planned actions to be followed to minimize property damage and loss of life. The plan assesses risks, identifies preparation/mitigation, recovery and preparedness measures with specific people-oriented actions (Figure 2).

Therefore, the plan is designed to ensure that NWEDC addresses issues and needs of vulnerable communities/groups residing in the vulnerable area in a sensitive manner. This plan guides the proposed project planning and implementation to identify and address impacts caused by disasters and ensures that information related to disaster preparedness is shared with the project affected families and communities in an appropriate fashion.

Figure 2: Key elements of disaster management



1.7 Profile of Rasuwa District

Located in 27˚2' to 27˚10' northern latitude and 85˚45' to 85˚08' eastern longitude, Rasuwa district covers an area of 1514 square km covering altitude from 314m to 7234m. It has one constituency 9 *Ilaka* (Region) and 18 village development committees. Physically, Rasuwa district can be divided in upper and lower region. Tibet autonomous area of China is located in the north of this district, Nuwakot district in the south, Sindhupalchok district is in the east and Dhading district is in the west. The population of the district consists of 9778 households with a total population of 43,300 (21,475 male and 21,825 female) as of 2011 census.

Geographically, it is remote area and its social, economic and developmental status is very low and from the last few years it is facing the terrible problem of landslide and through this more than 25 people has lost their life, many people have become homeless and have lost their property and fertile land. The living of northern and western part of this district has become very difficult and the people living in these regions are facing various problems as shortage of fuel, food etc. Rasuwa district is well known for religious places and tourism. For the religious importance Gosainkunda and other religious lakes lie in this district and also here are various temples of Hindus and Monasteries of Buddhists.

In recent years, Rasuwa district has been experiencing climate change and climate-induced disasters. The district is ecologically significant due to the presence of Langtang National park and range of Himalayan peaks that include Langtang peak of 7,227 m. Deforestation, pressure on land, depletion of water resources, physical remoteness and weak response capacity of the community, overall low preparedness and lack of awareness are some of the definite areas of concern. Increasing temperature is shifting the permanent snowline upward. This could cause a significant reduction of water storage in the district, which is likely to pose serious problems of water availability to many people living in the hills and downstream.

The climate of Rasuwa district varies from sub-tropical to temperate and alpine, but most of the area has temperate and alpine type of climate. The average annual rainfall is 994.3m, and occurs mainly during June, July and August. While the average maximum temperature in Dhunche is 22.6^0C, the minimum temperature stands at 11.5^0C. The mimimum temperature in Dhunche goes down to 0^0C and the maximum upto 25^0C. The cultivated land has sandy loamy soil whereas the high mountains and High Himalayan belts are mostly rocky with thin layers of sandy and loamy soil.

The average min monthly temperature pattern as observed from Nuwakot station is presented in the following Table:

Table 4: Average mean monthly temperature data from Nuwakot Station

Month	Mean temperature (^{0}C)	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)
January	20.17	23.73	17.85
February	22.63	27.04	20.06
March	27.20	30.04	24.48
April	30.90	33.80	25.79
May	31.47	34.41	27.50
June	30.67	33.06	28.26
July	29.77	31.82	27.36
August	29.92	31.79	27.97
September	29.34	30.79	26.73
October	27.89	29.50	25.75
November	24.70	26.83	22.20
December	21.37	25.94	19.02
Annual average	27.25	28.44	25.58

Source: Department of Hydrology and Meteorology, 2017

The weather stations near UT-1 HEP construction site is Timure, Nuwakot, Dhading, Thankot, Thamchi and Dhunche stations. The stations that can measure precipitation near headwork site are Timure, Thamchi and Dhunche stations and as Timure station is the nearest, annual precipitation data has been used from this station. The precipitation results are listed in Table 5 below:

Table 5: Precipitation measurement from the station near construction site

Station No.	Station Name	Year of Establishment	Elevation (amsl)m	Latitude/ Longitude	Annual Mean Precipitation	Monsoon Mean Precipitation	Max 24 hour Precipitation
1001	Timure	1957	1900	27°14'/85°25'	1039.2	812.8	191.2
1004	Nuwakot	1956	1003	27°55'/85°10'	1904.3	1556.3	140.6
1005	Dhading	1956	1427	27°52'/84°56'	1831.2	1454.0	180.4
1015	Thankot	1967	1631	27°41'/85°12'	1780.4	1411.8	300.1
1054	Thamchi	1972	1847	28°10'/85°19'	323.0	267.3	56.0
1055	Dhunche	1972	1982	28°06'/85°18'	1919.0	1534.4	106.8

Source: Department of Hydrology and Meteorology, 2017

Chapter 2: Plan preparation methodology

2.1 Study methodology

2.1.1 Literature review

Relevant literatures, including Environmental Impact Assessment (EIA), Detail Design Report, Land Acquisition and Livelihood Restoration Plan, Climate Change Risk Assessment Report, Local Benefit Sharing Plan, various publications of the Central Bureau of Statistics, profile of Rasuwa District Development Committee (DDC) and other relevant documents/reports related to environmental hazards and disaster management were collected and reviewed extensively to collect required data/information for the preparation of the Disaster Management Plan. This Disaster Management Plan draws upon the baseline data of RAP survey that has identified 142 vulnerable households (with social and economic indicators). Following publications were reviewed extensively to prepare the DM plan:

- EIA document of UT-1 HEP;
- UT-1 HEP Detail Design Report;
- UT-1 Supplementary ESIA, 2014;
- Population of Nepal, Population Census 2011, Central Bureau of Statistics;
- National Population and Housing Census 2011, Volume I, II and VI (National Report and VDC/Municipality Reports);
- Nepal Living Standard Survey (2010/2011), Statistical Report, Volume 1, CBS;
- Rasuwa District Profile;
- Village Development Committee Profiles of Haku, Dhunche and Ramche VDCs;
- Review of the National Strategy on Disaster Risk Management; 2011 ministerial guidance notes on disaster preparedness and response planning, Nepal Disaster Reports (2009 until 2014) published by the Ministry of Home Affairs;
- Local Disaster Response and Management Plan, National Adaptation Plan of Action (NAPA), Local Adaptation Plan of Action (LAPA), district disaster history (flood, landslides, epidemic, etc.); lessons learned documents (including good practices in disaster management); hazard & risk analysis of the district and demographic reports published by the Central Bureau of Statistics of project VDCs; and
- Review of national/ international environmental and social safeguard policies/instruments.

2.1.2 Field observation

In addition to the project affected VDCs, the scope of the field study covers downstream areas from the Dam site in Haku VDC to 39 kilometers south of Betrawati bridge, Nuwakot district. The probability of disasters was assessed on the basis of the vulnerability index of the people living in the project VDCs and their dependency on natural resources. The study team adopted a participatory approach with maximum involvement of different stakeholders of the project at the local and the district levels to generate relevant information on disaster management perspectives.

Field observation was carried out from November 7—16, 2017, at the proposed headwork and powerhouse sites, access road, upstream reservoir and downstream dam areas. The objective of the field survey was to establish the disaster management plan’s baseline vis-à-vis identify the legacy and emerging disaster issues of the existing project. A reconnaissance visit was undertaken along the downstream starting the dam site in Haku VDC further up to 39 kilometer downstream of the dam to assess the project's residual impacts on river morphology, sedimentation and river erosion and safety issues. Potential landslide sites along the area were also observed and sketched.

A total of six Key Informant Interviews and three Focus Group Discussions were conducted with families/communities to collect information on the downstream impacts, safety issues due to flushing of the reservoir and transportation activities. During field survey, consultation with concerned stakeholders, including project affected families, women groups, community forest user groups, etc. were accomplished. Apart from this, interaction was also conducted with the local people of Thulo Haku, Sano Haku, Mailung, Kalyanpur, Pahirobesi and Betrawati areas to collect information about the vulnerabilities posed due to natural hazards and other relevant aspects. Discussions with the officials of Langtang National Park, District Forest, Soil and Watershed Conservation Offices and Nepal Red Cross Society were also held to collect information on their activities related to disaster risk reduction.

2.1.3 Participatory Capacity and Vulnerability Assessment (PCVA)

According to the approved Land Acquisition and Livelihood Restoration Plan (LALRP) of UT-1 HEP, 142 families have been identified as economically affected households whose livelihood is affected as a result of land loss. PCVA was also conducted to the broader vulnerable communities to identify risks that the community faces and how people overcome those risks through their coping capacity assessment. People's perception of risk was considered by analyzing vulnerability of a community and the type, causes, nature and intensity of the hazards that it faces because of disasters.

Figure 3: Step by step guide followed to the PCVA process.

PCVA mainly focused on understanding people's previous experiences with hazards that enabled them to develop coping strategies; analyzing which resources are available and used by the community to reduce risk, who has access to these resources and who controls them; assessing community capacity of people at risk; prepare seasonal calendar and prioritizing disaster risks in the project area. Vulnerable or potentially vulnerable localities of the project affected VDCs were identified by the existing hazards they face and the stresses and disastrous events and losses suffered in the past. Secondary information from documents and records in DDC and project affected VDCs were collected, analyzed and collated. Thereafter, vulnerable areas were grouped together on the basis of the hazards they face, e.g. VDCs vulnerable to flood, VDCs vulnerable to landslide, VDCs susceptible to GLOF, etc.

Ranking of the project affected VDCs according to their vulnerability status was discussed with the representatives of various stakeholders–members of District Disaster Management Committee (DDMC), political party representatives, relevant CBOs/NGOs, district level experts and VDC representatives. These deliberations provided an opportunity in minimizing conflict of interest and reduced time taken to reach consensus as to the vulnerability category of each VDC. The ranking identified the most vulnerable VDCs that needed to be prioritized for the development of disaster management plans and the implementation of risk reduction initiatives. In doing so, HECT Consultancy conducted Participatory Capacity Vulnerability Analysis (PCVA) to assess vulnerabilities and risks and devise strategies to deal with different hazardous situations by involving communities, VDCs and district line agencies.

2.1.4 Community/stakeholder consultations

The identified key stakeholders of the DM Plan are potential vulnerable areas downstream of the dam along both sides of the river, most notably, indigenous *Adibasi/Janjati*, vulnerable groups (*Dalit*s, women, minor ethnic groups, etc.), Community Forest User Groups (CFUGs), women-led organization, teachers and elderly people of the downstream area. During consultations held in Pahirobesi and Betrawati, utmost care was taken to ensure that representatives of the most vulnerable communities are represented as they are hardest hit in the event of a disaster. The identified stakeholders were consulted through free and prior informed consent to solicit their views and concerns regarding the potential impact of disasters.

2.1.5 Data collection

Relevant information was collected from the project affected VDC records and from communities by using checklist. Data included information on the number and group (age, gender) of people, assets and livelihoods, natural resources and infrastructure affected by locally occurring hazards. On the other hand, different information was collected on the existing coping capacity of local communities and stakeholders to manage the impacts of hazards and shocks, and the availability of services and facilities (health posts, shelters, ambulance, fire service and trained personnel). The information from community discussions and checklists were cross-checked against the information recorded in relevant VDC offices. The information gathered from ward level assessments and that collected from primary and secondary sources was used in unison to cross check its validity.

Given below in Table 6 is the study focus areas with scope of work:

Table 6: Study focus areas

Study scope	Outcome indicator	Area of analysis	Methods	Tools
1. Conduct vulnerability assessment	- Participatory Capacity Vulnerability Assessment (PCVA)	- Household information - Caste, ethnicity and religion - Socio-economic status - Hazard mapping - Community coping capacity	Trained and experienced researchers were mobilized to facilitate discussions with project affected communities	Questionnaire

Study scope	Outcome indicator	Area of analysis	Methods	Tools
		- Existence of physical infrastructure - Understanding the impacts of a hydropower project on local communities		
2. Carry out Key Informant Interviews	6 Key Informants (affected families, DCC, VDC secretary, CDMC officials, LNP, DSCO, DFO, DADO, NRCS, CFUG, etc.	- Available public services and infrastructure at community level - Major disaster management programs at community level - How program interventions support to improve community people's livelihood - Services received from the project	- In-depth interviews with Key Informants to collect information about the level of impact at VDC level to initiate disaster management mechanism	KII format (semi structured questionnaire)
3. Conduct FGD with key stakeholders	3 FGDs (one FGD in each study VDC)	- Impact of disaster in the HEP-affected community	- FGD with selected local stakeholders	FGD guidelines

2.2 Vulnerability analysis

The information received from PCVA, FGD, KII and community level consultations were verified and thoroughly checked to minimize errors in addressing the core causes of vulnerability and devising preparedness measures. and precede variables coding prior to the data entry. The problem tree was transformed into solutions tree by formulating an opposite statement for each of the problems and causes which provided a visual representation of what can be done to address the causes of the problem.

All the information thus generated was very useful in developing a realistic and implementable disaster management plan on the project affected community's vulnerability to hazards and capacities existing locally to reduce potential risk of disasters. In fact, the analysis helped in shaping how communities prioritize investments for sustainable development, enabling communities and stakeholders to identify long-term solutions associated with strengthening resilience and evidence-based planed interventions. The PCVA is expected to empower communities to mitigate against effects of disasters and also raise public awareness, sensitizing the community on causes of vulnerability and illustrate ways in which those vulnerabilities can be reduced.

Chapter 3: Dam break/inundation analysis

3.1 Climate and hydrology

In general, humid wet climate during summer and dry climate during winter is expected in Nepal. As the monsoon season starts, cloudy sky and high precipitation are expected for 3 ~ 4 months. Usually 70 ~ 80 % of entire annual rainfall occurs during this season. The rainfall pattern shifts from east to west, highly affects the rainfall intensity with decreasing trend in the region. The construction site is located at higher Himalayan region, so the geological characteristic affects the climate. The climate condition varies from subarctic region to subtropical region depending on elevation. During June to September, the southwest seasonal wind influences climate very much in the country as well as in the region too.

The main source of recharge for the catchment area is the precipitation on the high altitudinal regions. Precipitation in form of snow and ice during rainy season gets accumulated and provides discharge during pre-monsoon season (dry period) by melting. Hydrological observation is done in nearby areas of the Upper Trishuli-1 HEP. The stations near construction site are Syaprubeshi 446.25 of Bhotekosi River, Syaprubesi 446.2 of Langtang Khola River, Dhunche 446.3 of Trishuli River, Betrwati (446.7) 446.8 of Phalakhu Khola River, Betrawati 447 of Trishuli River, and Bhorletar 449.95 station. Each station is located in upper part of headwork site. The data from Betrawati streamflow gauging station is used where the location is at junction of Trishuli River and Phalakhu Khola River and also has the data collected from 1967.

3.2 Identification of risk assessment, vulnerability and capacity analysis

Any hydroelectricity project, if not designed on the sound principles of design after detail investigations in respect of hydrology, geology, seismicity etc., could spell a large-scale calamity. Although the detailed field investigations have ensured that the dam is constructed on firm foundation, designed for suitable seismic design parameters, yet in view of that uncertain element of “force mejure”, the eventuality of a disaster cannot be ruled out which calls for preparing a preparedness plan to confront such an exigency without being caught in the vast realm of unpreparedness.

The National Strategy for Disaster Risk Management (NSDRM) of the Government of Nepal calls for Identifying, assessing and monitoring disaster risks and enhance early warning; integrate DRR considerations into infrastructure development planning and implementation; and enhance preparedness for effective response. The strategy states that insufficient disaster awareness amongst the development partners and communities fail to appreciate strong correlation between hazards and vulnerabilities (existing and accumulating) and their interplay converting even a minor hazard event into recurring disasters, which erode the hard-earned development gains and undermine economic viability of communities and affected area.

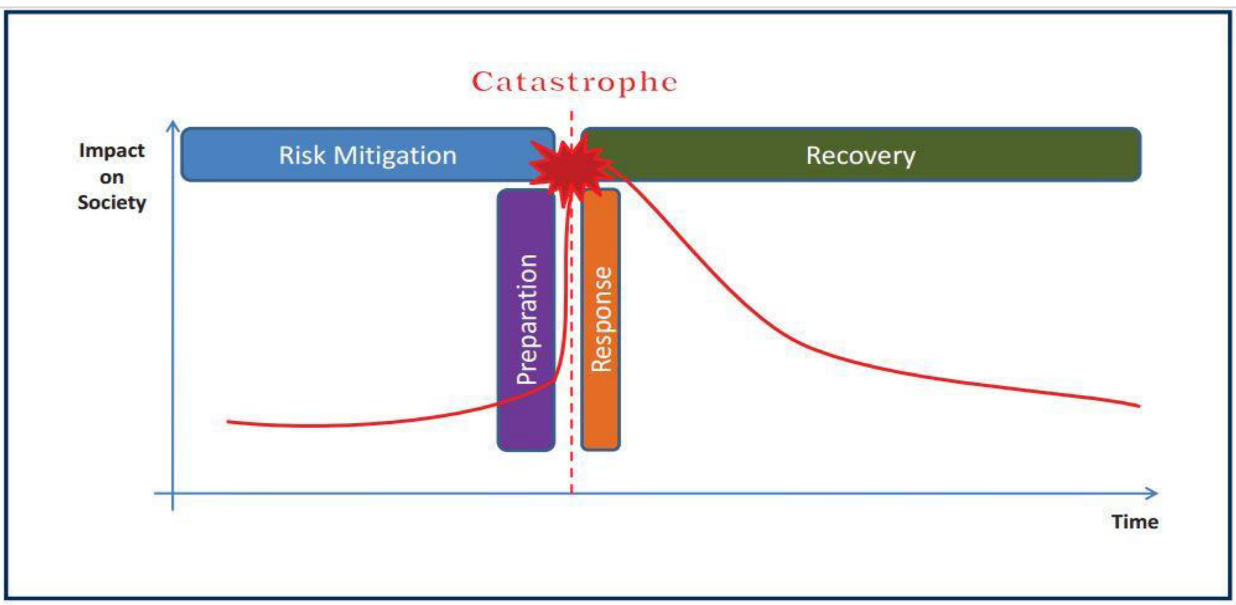
Development of hydropower poses a multitude of risks. Lack of resources and inadequate technical capacities to mainstream disaster into hydropower development planning (including financial resources to deal with disaster/emergencies) have cumulatively posed to be a great challenge. Weak coordination mechanism, lack of awareness and simulations, lack of updated district disaster management plan, absence of multi-hazard, vulnerability and risk assessment which act as a foundation for disaster management plan, therefore, calls for a paradigm shift from reactive to proactive approach and as a result, institutions are in place to more focus on preparedness and mitigation and well-coordinated emergency response. One of the importance of multi-hazard vulnerability and risk assessment approaches is, therefore, to assess in terms of frequency, severity and geographical impact of hazard and its priority in decision-making process.

3.3 Enhancing resiliency

Assessment of hazards and risk is a continuous process. Reducing risk through enhancing resilience requires an integrated planning process to make sure that HEP structures are resilient to current and future hazards. This involves: (a) land use management; (b) better environmental monitoring; (c) enhanced supervision of HEP construction and building end use; and (d) retrofitting existing structures for increased resilience. The approach is to adopt resilient measures such as disaster preparedness, mitigation, response and recovery. Therefore, to save life and property, an integrated disaster management approach is essential, which includes preventive measure, mitigation, preparedness, response, recovery and rehabilitation.

Increasing people's resilience means addressing the factors that underlie their vulnerability as illustrated in Chart 2. Improving people's livelihoods means that they have more options available and can choose to live or work in areas less exposed to hazards, or at least have more resources to draw on in order to cope and recover when they are affected by negative events. Being better prepared for hazards and stress can significantly reduce exposure. In the event of any disaster, NWEDC needs to adopt the Vulnerability to Resilience (V2R) approach through proactive preparedness, timely response and effective recovery at outlined in Chart 1 below:

Chart 1: A schematic diagram of disaster risk mitigation approach



Source: World Meteorological Organization

Identifying hazards and determining its likelihood and impact is the first step in the analytical process. Even in planning for a specific emergency, it is important to begin with a broad analysis of potential hazards affecting the HEP to ensure that the full range of risks are considered. Risk analysis in this regard considers two dimensions: (a) the probability or likelihood of a hazard occurring, and (b) the potential humanitarian impact of the hazard in both upstream and downstream communities.

On resources vulnerability front, there could be some uncertainties associated with the whole hydrological cycle. Hydrological cycle itself is a complex system and the climatic and hydrologic changes may add more uncertainties to its complexities. The hydropower plant may not function with designed capacity as the variation in flows might vary (may increase for short time and decrease after a longer period of time). The most critical impacts can be on water supply infrastructure and facilities, which could be at risk from increased flooding, landslides, sedimentation and more intense precipitation events (particularly during monsoon). Greater unreliability of dry season flows, in particular, may pose potentially serious risks to water supplies in lean season. Therefore, increased climatic variability poses risks to power generation.

Amongst all the hazards, the first and foremost hazard is active landslide to which Rasuwa district is highly prone and occurs every year during monsoon season. These landslides are considered to have the highest degree of impact or the frequency of occurrence that adversely affect people and environment of the project area. While mitigation and preparedness efforts can lessen the impact and severity of these hazards, its vulnerability and risk associated cannot be eliminated. However, proper assessment of the vulnerability, risk along with mitigation and preparedness efforts can lead or invite attention towards those hazards which need proper mitigation and preparedness plans with which NWEDC will be better equipped to prepare and respond to disasters, limiting impacts to the people, economy, environment and property of the project area.

3.4 Active landslide

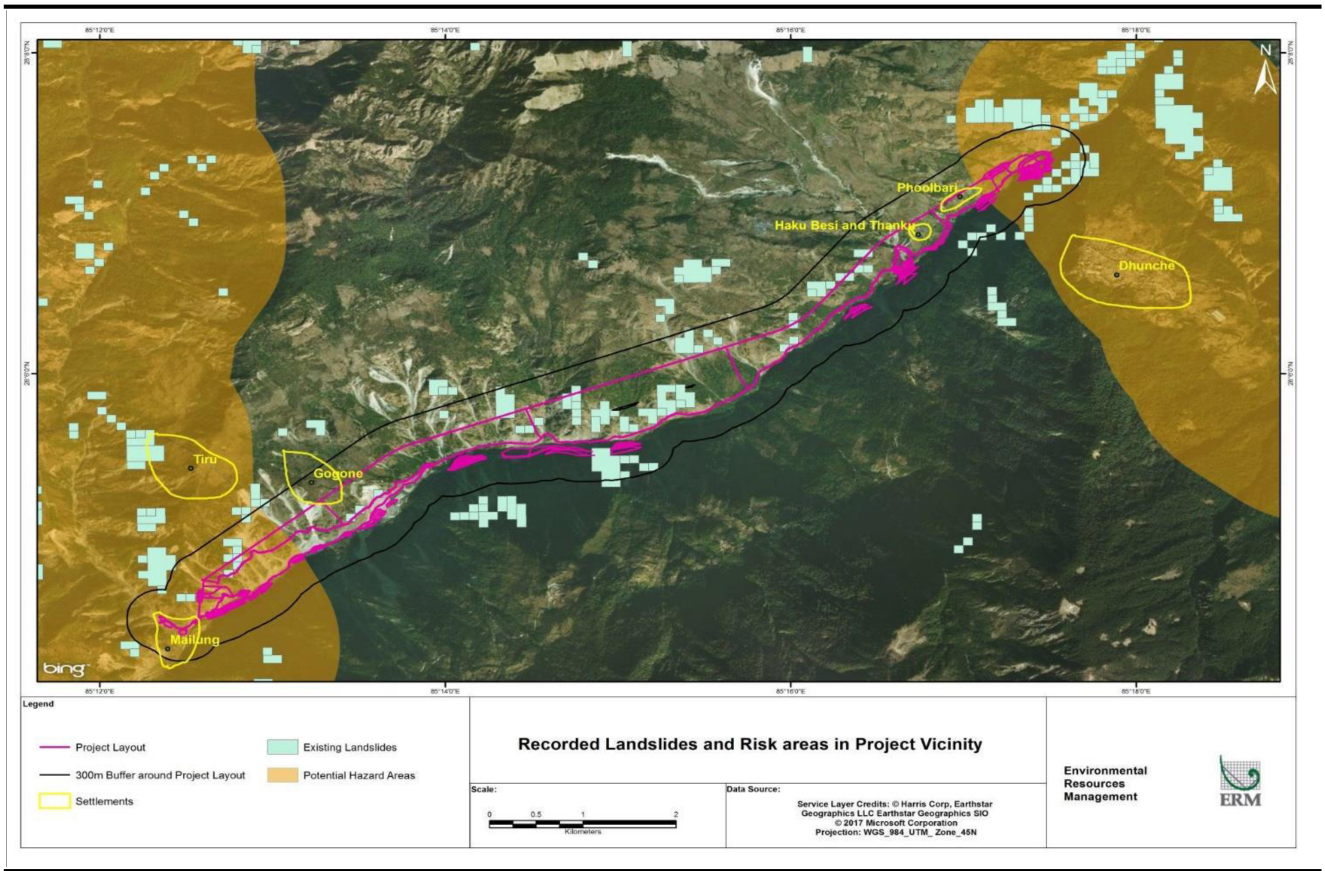
Rasuwa lies in the sub-tropical and temperate zone. The district is subject to heavy rainfall due to its location in the direct path of monsoon. There is a high degree of variation in climate and vegetation, which ranges from sub-tropical to alpine depending on its altitude. Altitude is the main factor controlling climate and weather conditions of the district. Low temperature, high rainfall on windward slopes and comparatively dry on leeward side, and heavy precipitation in the form of snow at the mountaintops are the main features of climate in the district. Due to great variation in sharp edged mountains, there is also a variation in rainfall and temperature and varies with altitude and slope aspects.

The Ramche landslide is located at the 36-km sector of the Trisuli-Dhunche highway in Rasuwa district. This landslide first activated in 1983 and reactivated in 14 August 2003 killing 23 army men on the site and injuring many others. Since then the landslide is active. Reduced soil strength due to pore water pressure together with vibration of land due to heavy traffic have caused the debris to flow downslope on the rock surface. The slide seems more active in the monsoon time and relatively stable in the winter. The movement rate is more than a meter per year. It has developed several cracks on the surface causing collapse of houses. The slide has put more than 100 people and their cattle living in 16 houses of Polchet village and at immediate risk.

Aside from geology and fragile soil type of mountain ranges, especially in the upper reaches of the district, accelerated deforestation and degradation of natural slopes are major causes behind increase incidents of landslides. Small isolated landslides occur frequently in areas with no tremendous impact on the built system while the slides generated by floods, earthquakes and heavy snow burden brings consequences to lives, property and critical facilities. In Rasuwa district, noticeable landslides occur in the months of May, June, July and August.

It has also been noticed that sudden heavy rains occur mostly in northern Rasuwa resulting in devastating loss to human life and property. As a result of landslides, several link roads become temporarily blocked in the project VDCs thereby obstructing mobility and leading to the collapse of vulnerable houses and road pavement cracks. The vulnerability of local people multiplies with settlements in landslide-prone areas due to population expansion, lack of awareness, poverty and lack of resources. Map 2 below shows recorded landslides and at-risk areas.

Map 2: Recorded landslides and at-risk areas



Source: Land Acquisition and Livelihood Restoration Plan (2017), NWEDC.

3.5 Glacial Lake Outburst Flood (GLOF)

Nepal is highly dependent on rivers fed by glaciers for freshwater resources. Hydropower is an important energy source for economic development in Nepal. It has been estimated that Nepal's hydropower potential is about 83,000 MW (Shrestha, 1985). However, the installed capacity in the country to date is about 900 MW, which is about 0.90% of the theoretical potential. Majority of the planned HEPs are located near the headwater regions of the Himalayas and several of these projects are envisaged to include reservoirs for storage of hydropower. Consequently, their vulnerability to glacial lake outburst floods is likely to increase significantly.

As Nepal has experienced several instances of GLOF, its impact on people's livelihoods needs to be considered, especially for poor and marginal mountain farmers. The Trishuli river basin stretches from East to West, and 50% of the entire drainage area is located in China. Trishuli river flows into Bhotekoshi in Nepal. There are 74 glaciers areas exist in Trishuli river in Nepal. The 74 glaciers consist of an ice cap, 19 ice apron glaciers, 36 mountain glaciers and 9 valley glaciers. Among those, the 9 valley glaciers take 66 % of the entire glaciers area, and 81 % of ice storage. In Trishuli river, glaciers were investigated mostly in the southern west and northern east areas. In the southern areas, only 6 glaciers exist, however, it has the largest areas comparing with glaciers in other regions.

The Langtang glacier, located at approximately 28^{0}30" N latitude and 85^{0}30" E longitude, ranges in altitudes from 4500–7000m and has a surface area of 75km^2. Almost 47% of Langtang glacier is covered by debris. However, the debris thickness is unknown. The Langtang glacier, considered to be the longest glacier in Nepal, is about 36.6 km far from the headwork site. Apart from this, two major glaciers have been identified at a distance between 36 and 41 km from the weir site. Amongst the three identified glacial lakes, Langang, Longda and Khymjung, none others have been included under the high-risk GLOF category (EIA Report, NWEDC).

Table 7: Distribution of glaciers with basic aspects in Trishuli river basin

Aspect	Number	Area		Largest Area (km^2)	Smallest Area (km^2)	Longest length (m)	Shortest length (m)	Highest Elevation (m)	Ice reserve (km^3)
		Km^2	%						
SE	11	50.57	20.5	16.46	0.15	11,590	500	7,051	4.64
SW	19	49.43	20.0	25.65	0.07	5830	315	6892	4.83
S	6	82.50	33.4	67.93	0.17	17,740	760	7,218	13.30
NE	18	16.23	6.6	2.49	0.02	3350	315	6279	0.76
N	7	18.25	0.1	6.55	0.07	5,700	315	6,195	1.36
E	1	0.13	0.1	0.13	0.13	630	630	5456	0.00
NW	8	27.63	11.2	16.52	0.18	6,330	410	7,051	2.54
W	4	1.94	0.8	1.17	0.01	2850	150	5791	0.07

Source: UT-1 HEP Detail Design Report II

Considering examples in the past, the peak flood during GLOF occurs at the downstream of outburst area. Due to the dissipation effect of the channel and reservoir, the flooding will be reduced as time goes and it passes further distance. That means the peak flood will be reduced as being away from the outburst area. Basin area of the lake as well as section of the river and reservoir capacity will affect the reduced amount from the flooding. The distance from the glacier lake at Trishuli river basin to the weir site is approximately 30 km—60 km, which is quite a long distance. Therefore, the peak flood occurred at the demolition area will be highly reduced at the head work site so that the affect will be considered to be subtle. Furthermore, as investigated above, the glacier does not melt in monsoon season, and melting will occur in spring or autumn. Therefore, it is considered that it will not affect the design flood, which is likely to occur in monsoon season.

3.6 Earthquake

As in other parts of Nepal, Rasuwa district is also highly vulnerable to earthquakes. Several studies have determined that Nepal's existing infrastructure, communication systems and medical sector are inadequately prepared for earthquakes. This lack of preparation is a major threat to life and property in the event of an earthquake. The presence of Rasuwa district in the most active seismic zone (Zone 5) also indicates that earthquake is a potential hazard in the district based on the available faults and epicenter data of the Western Development Region.

Like other parts of the Himalayas, the area of Upper Trishuli-1 HEP site is located within the system of Himalayan thrust where seismicity is related to the north-northeastward movement of the Indian tectonic plate. The major feature in the region of UT-1 HEP is that the distribution of magnitude and epicentral distances for the earthquake ranges within 500 kilometers of the HEP site and is scattered very widely. This may be due to inaccuracies in the epicentral location as well as dipping nature of the tectonic features. From Table 8, it is observed that there are several events close to the project site, with most of them having magnitudes below 6.4 and the recent mega earthquake of April 25, 2015 at 7.8 Richter scale.

Table 8: Major earthquake events in the Himalayan tectonic belt

Place	Date	Magnitude	Distance (km)
Eastern Nepal	26.08.1833	7.6	364
India-Nepal border region	04.10.1833	6.5	324.3
Darjeeling (West Bengal, India)	01.05.1852	7.0	370
Nepal-India border region	23.05.1866	7.0	466.5
Nepal-India border region	07.07.1869	6.5	466.5
Nepal-Bihar border	15.01.1934	8.1	160.5
Nepal-India border region	20.08.1988	6.8	180.1
Nepal-India border region	18.09.2011	6.9	155
Western Nepal (Gorkha District)	25.04. 2015	7.8	100

Source: National Seismological Centre, Department of Mines and Geology, 2017

Based on the past experiences and literature review, the following hotspots (Table 9) with likely impact have been identified:

Table 9: Risk profile and hotspots

Hazard	Hotspots	Likely impact	Probable months
Earthquake	Entire project area	• Human lives lost • Houses, hospital, school and other infrastructure damaged • Can trigger landslide or dam break	Anytime

Flood/flash floods	Areas along Trishuli river at both banks	• Human lives lost • Houses damaged • Vector/water-borne diseases • Heavy soil erosion	June-September
Landslide	Entire project area	• Human lives lost • Houses damaged	July-October
Strong wind	Entire project area	• Houses blown away • Cash crop destroyed	April
Public health Emergency	Entire project area	• Human live lost • Livestock lost	Anytime

3.6.1 Impact of earthquake in project area

Nepal was struck by 7.8—8.1 magnitude earthquake on April 25, 2015. The earthquake killed nearly 9000 people and injured over 22,000. The epicentre of this earthquake and its aftershocks was located at Barpak, east of Gorkha district that adjoins Rasuwa district. Rasuwa district, where UT-1 project is located, was one of the worst affected areas that damaged more than 80% of the houses in the project footprint area (3 VDCs accounting for about 500 HHs) and resulted in more than 200 deaths in the area (43 people working in the project site). The earthquake also resulted in significant impacts on the access road being constructed for the project.

The earthquake of April 2015 caused sizeable losses to the people residing in Rasuwa district at large. The local community in the project area suffered impacts pertaining to loss of life and movable and immovable property, loss of livelihood, physical injuries, psychological trauma and damage to agricultural land. The following figure (Table 10) provides an understanding of the impacts from the earthquake, as recorded by the Rasuwa District Disaster Relief Committee.

Table 10: Summary of earthquake effects in project area

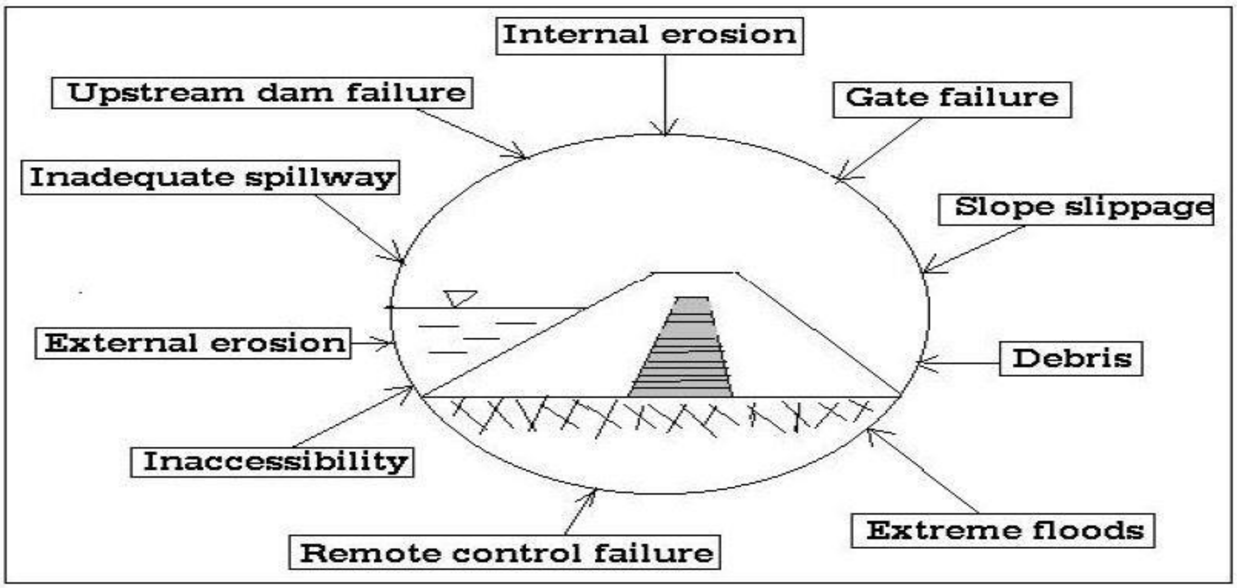
Loss of lives			**Loss of households/sheds**		
VDC	**Population**	**Dead**	**No. of HHs**	**Completely destroyed**	**Partially destroyed**
Haku	2169	96	704	702	2
Dhunche	2744	15	714	704	0
Ramche	2268	29	834	586	0

3.7 Dam break/inundation analysis

The purpose of the dam break analysis is to illustrate how the flood wave propagates downstream of dam, and determine time required by hydrodynamic wave to reach downstream inhabited areas, which is crucial for the design of alarm systems, evacuation plans and hazard maps. This is required to assist NWEDC in the preparation of evacuation plans, planning of warning systems for alarming and for hazard classification of affected areas. The available information has been used to analyze risks posed to individuals or populations, property or the environment, from dam break through scope definition, hazard identification and risk estimation.

Dam failures are often categorized as static, hydrologic or seismic. In the case of UT-1 HEP, natural disasters such as floods and earthquake are of great concern as they may result in overtopping, erosion, etc. Some of the underlying factors are presented in Figure 4.

Figure 4: Potential contributing factors for dam failure



Building a dam ensures a large number of potential benefits. But it also creates a structure with potential hazards, which may result from its failure. When a dam fails, huge volume of water stored transforms into a flood wave, which may cause severe damages to life and property situated downstream. The effect of such a flood disaster can be mitigated to a great extent if the resultant magnitude of flood peak and its time of arrival at different locations downstream of the dam can be estimated, facilitating planning of emergency action measures. This warrants dam break modeling, which assesses the flood hydrograph of discharge from the dam breach and maximum water level at different locations of the river downstream of dam due to propagation of flood waves along with their time of occurrence.

In spite of great advancements in design methodologies, failure of dams and water retaining structures continue to occur. Dam break is most likely to occur during monsoons under the occurrence of extremely heavy storms (when there is hardly any storage space available in the dam). Dam may breach on account of some structural failures or faulty maintenance. In this condition, the outflow from dam will be combined with lateral inflows from the areas downstream of the dam. The instances of dam breaks establish that hazard posed by dams, large, and small alike, is catastrophic. As public awareness of these potential hazards grows and tolerance of catastrophic environmental impact and loss of life reduces, managing and minimizing the risk from individual structures has become an essential requirement, rather than the employment of a simple management plan.

3.7.1 Dam break modelling process

Modeling process is approximation of a physical phenomenon through which the physical phenomenon and its effects can be studied. Thus, as in the case of any other modeling process, dam break modeling has inherent approximations through assumptions. The foremost assumptions are in the hydrodynamic equations which are derived on the basis of the following assumptions:

- The water is incompressible and homogeneous, *i.e.* without significant variation in density.
- The bottom slope is small.
- The wave lengths are large compared to the water depth. This ensures that the flow everywhere can be regarded as having a direction parallel to the bottom, i.e., vertical accelerations can be neglected and a hydrostatic pressure variation along the vertical can be assumed.
- The flow is sub-critical.

Other assumptions are associated with the breach parameters, especially, breach width and breach depth, which has significant impact on flood peak and arrival times. Dam break floods create a large amount of transported debris. This may accumulate at constricted cross sections, where it acts as a temporary dam and partially or completely restricts the flow, resulting variation in water level at the downstream locations. This aspect has also been neglected due to limitations in modeling of such a complicated physical process. This limitation also has an effect on the conservative side only. Even with the assumptions outlined above, dam break modeling serves very useful purpose, as it provides reasonable extent of inundation under different situations enabling preparation of the Disaster Management Plan. A flow chart for two-dimensional mathematical modelling is given in Figure 5.

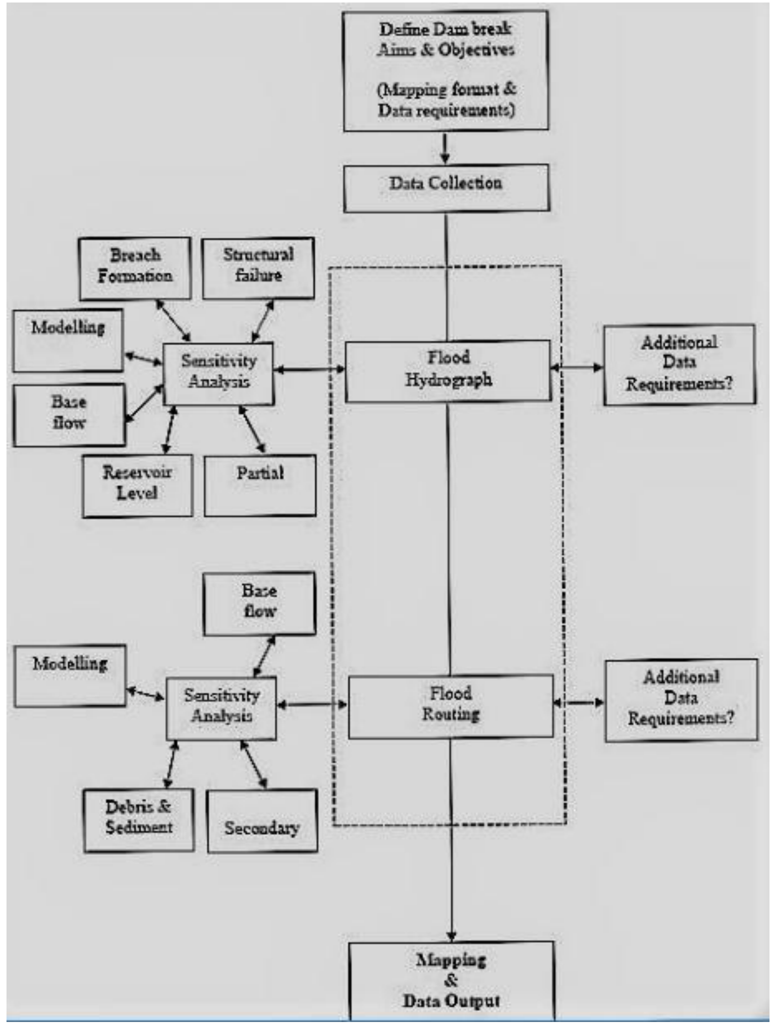
The extreme nature of dam break flood means that flow conditions will far exceed the magnitude of most natural flood events. Under these conditions, flow will behave differently vis-a-vis conditions assumed for normal river flow modelling, and areas will be inundated that are not normally considered. This makes dam break modelling a separate study for the risk management and disaster management plan. The objective of dam break modelling or flood routing is to simulate the movement of a dam break flood wave along a valley or indeed any area downstream that would flood as a result of dam failure. The key information required at any point of interest within this flood zone is generally:

- Time of first arrival of flood water;
- Peak water level–extent of inundation;
- Time of peak water level;
- Depth and velocity of flood water (allowing estimation of damage potential); and
- Duration of flood.

The nature, accuracy and format of information produced from a dam break analysis will be influenced by the end application of the data. In preparing the Disaster Management Plan for UT1 HEP, a two-dimensional mathematical dam break modeling simulation was carried out in November 2017. A computer-based modern modelling simulation tool was applied to analyze the possible chances of dam break that covers the governing flow equations of continuity and momentum. A flow chart for mathematical modelling is given in Figure 5 below:

A two-dimensional mathematical modelling of dam break analysis was carried out in which besides the information about the magnitude of flood, *i.e.*, discharge and water levels, variation with time and velocity of flow, additional information about the inundated area, variation of surface elevation and velocities has also been analyzed. As Trishuli River widens downstream of dam and large area is likely to be flooded, two-dimensional analysis has been undertaken.

Figure 5: Flow chart of dam break modelling process



The basic theory for dynamic routing consists of two partial differential equations originally derived by Barre De Saint Venant in 1871. The equations are:

i. **Conservation of mass (continuity) equation**

$(\partial Q/\partial X) + \partial(A + A0) / \partial t - q = 0$

ii. **Conservation of momentum equation**

$(\partial Q/\partial t) + \{ \partial(Q2/A)/\partial X \} + g A ((\partial h/\partial X) + Sf + Sc) = 0$

where Q = discharge;
A = active flow area;
A0 = inactive storage area;
h = water surface elevation;
q= lateral outflow;
x = distance along waterway;
t = time;
Sf = friction slope;
Sc = expansion contraction slope and
g = gravitational acceleration.

For any dam break study, it becomes extremely difficult to predict the chances of failure of a dam as prediction of dam breach parameters and timing of breach is not within the capacity of any of the available mathematical models. However, assuming that dam fails, the important aspects to deal with are, time of failure, extent of overtopping before failure, size, shape and time of the breach formation. Estimation of the dam break flood will depend on these parameters.

The breach characteristics that are used as input to the existing dam break models are: (a) final bottom width of the breach; (b) final bottom elevation of the breach; (c) left and right side slope of the breaching section; (d) full formation time of breach; and (e) level of dam at the time of the start of breach. Therefore, the breach formation mechanism is, to a large extent, dependent on the type of dam and the cause due to which the dam fails. As per the UK Dam Break Guidelines and U.S. Federal Energy Regulatory Commission (FERC) Guidelines, in case of earthen and rock fill dam, the breach width should be taken between 1.0 to 5.0 times height of dam and full formation time should be taken of about 1 hour. Hence, the final bottom elevation of the breach for sensitivity analysis has been taken corresponding to relatively weaker locations in the dam.

The proposed UT-1 HEP comprises of concrete gravity structure across the Trishuli River with the dam top being at EL 1276 m. The dam height is 28 m from the deepest foundation level. The dam shall be provided with spillway and crest level has been kept to pass a discharge of PMF at reservoir level.

A rectangular breach at an El 1277 masl with side slope 1.0 and breach formation time as 0.5 hour have been considered in the study for dam break analysis of UT-1 HEP. After the breach, immediately below the dam, the maximum flow will occur. The magnitude of the simulated outflow hydrograph will be 3059 cumec corresponding to maximum stage elevation 1277 masl at 0 km. assuming that breach occurs in rainy season, there will be significant water flow contribution from the tributaries downstream such as Mailung Khola, Betrawati River and small tributaries. The flow contributed from these tributaries will be almost equal to the decrease of flow due to flood. Going back at the historical dam breach data, the breach has normally occurred due to avalanche in past which eroded the side banks with not much loss of properties in UT-1 HEP section. The chances of dam breach normally occur in rainy season. Hence, the assumption of dam break during winter is highly less probable, thus not considered in the analysis.

The manner in which the failure is to commence can be specified as one of the following: (a) at a specified stage (water surface elevation) of the reservoir and duration; (b) at a specified time; and (c) at a specified stage (water surface elevation) of the reservoir. The analysis points out the need to assess the water level at different locations downstream due to the occurrence of Standard Project Flood (SPF) and without any dam breach.

3.7.2 HEC-RAS model

The Hydrologic Engineering Center's Geographical River Analysis System (HEC-GeoRAS) or HEC-RAS has been developed by US Army Corps of Engineers Hydrologic Engineering Center and it is available worldwide with other supportive documents. The HEC-GeoRAS is a GIS extension with a set of procedures, tools, and utilities for the preparation of river geometry GIS data to import into HEC-RAS and it is used to generate the final inundation map. The input data required for the River geometry preparation using the HEC Geo-RAS model are Triangular Irregular Network (TIN), DEM, and land use. The river geometry file and stream flow data are the input files for HEC-RAS to generate the water surface level along the River. The HEC-Geo-RAS or HEC-RAS has been used worldwide for inundation mapping purpose.

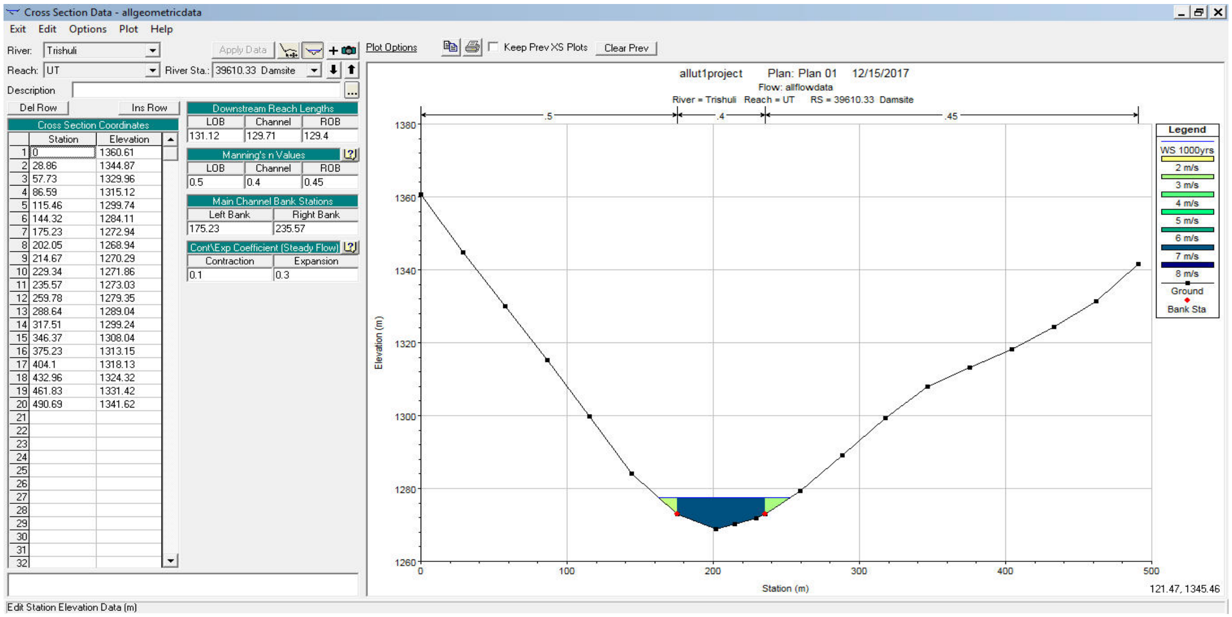
For the purpose of dam break analysis, HEC-RAS modelling was carried out to undertake dam break flood modelling aimed at ensuring right balance between modelling accuracy and cost in terms of time spent developing the model setup. HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment. The system comprises a graphical user interface, separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities. The model contains advanced features for dam break simulation.

The present version of HEC-RAS system contains two-dimensional hydraulic components for (i) steady flow surface profile computations; and (ii) unsteady flow simulation. The steady/unsteady flow components are capable of modelling subcritical, supercritical, and mixed flow regime water surface profiles. The system can handle a full network of channels, a dendritic system, or a single river reach. The graphics include X-Y plots of the river system, schematic cross sections, profiles, rating curves, hydrographs, and many other hydraulic variables. Users can select from pre-defined tables or develop their own customized tables. All graphical and tabular outputs thus generated from the study have been kept in Annex below.

For the purpose of this study, the SRTM (Shuttle Radar Topography Mission) digital elevation model (30-meter horizontal resolution) of the US National Geospatial Intelligence Agency and NASA has been taken. The cross-sections, river channels, bank lines and flow paths were generated using SRTM DEM. The Manning's roughness co-efficient was applied according to Manning's table. In case of channel, 0.04 roughness co-efficient and in case of left bank 0.05and for right bank 0.045 roughness co-efficient was applied.

In addition, DEM (Digital Elevation Model) was processed to create TIN (Triangular Irregular Network). After that, the dem was overlaid over the real google imagery and the river cross-sections, stream centerline, stream bank lines, flow lines, and other river geometry information were extracted from DEM for HEC-GeoRAS model. At the same time, the land use was processed to get the Manning's n value for individual cross-sections. After the RAS geometry data preparation, the HEC-GeoRAS model was used to generate RAS GIS import file (final river geometry file) that can be used as input for HEC-RAS. Figure below shows the cross-section profile of just the downstream of intake in case of rectangular breach discharging 3059 m^3/s. Other inputs considered are design flood hydrograph, breach geometry, dam elevation at the start of failure and initial water elevation at downstream end of channel; description of downstream flow condition, drainage density, cross-sectional area, channel bed slope and geometry of the overbank areas. This shows that at the time of breach, the velocity of water is 7m/s in the channel and it is 2-3m/s for both the overtopping banks.

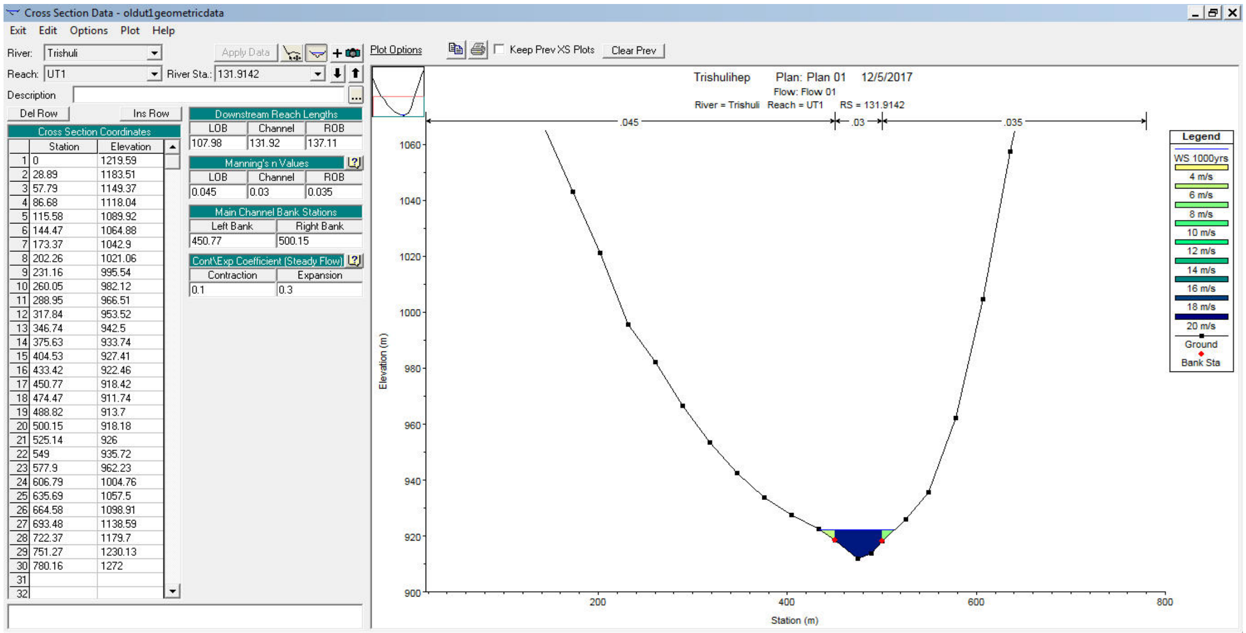
Figure 6: Cross-section profile of intake in Hakubesi VDC



As the slope is very high in upstream section of the intake damsite of UT-1 HEP, the flood velocity is 7 meter per second with flood depth from bed being 11 meter. In yearly flood condition of 625 cumec, the water level is 5 meter high from the river bed. However, in the event of flooding, the water rises additional 6 meter totaling the maximum depth of 11.97 meter. According to the hydrological data provided by the Department of Hydrology and Meteorology (DHM) of Betrawati, the rainfall-induced flood had crossed 2000 cumec in 1972, 1973, 1985, and 1996. Similarly, when the data is transformed from Betrawati Station to UT1 HEP intake site, the corresponding year has crossed the 100-year return period flooding event.

Upstream water level plays important role in the dam break flood, NWEDC has to ensure a degree of alertness in the downstream areas, especially near the powerhouse area although it is safe but in a vulnerable zone, also there are some sporadic settlements as well as agricultural fields along the left side of the river bank near and downstream of the powerhouse areas. If the upstream water level rises above the dam top, the UT-1 dam being a concrete dam, distress may occur. If, however, the dam fails, it may be considered as a disaster condition and at this situation, nothing can be done to prevent the hazardous disaster from occurring of this event. Information of this conditions should be immediately passed on to the Engineer-In-Charge and the District Administration Offices in Nuwakot and Dhading districts.

Figure 7: Cross-section analysis at Mailung powerhouse



3.7.3 Hydrological data analysis

In this study, the hydrological analysis deals with the flow analysis to obtain the mean monthly flow at the provided point of reference using catchment correlation, flood at different return periods and in short it provides a basis of forecasting. For this purpose, hydrological data from Betrawati Station Number 447 was used and the data was analyzed using catchment area ratio method. For flood frequency analysis Gumbel's extreme value distribution was used.

Hydrological data particularly water level and discharge data, was analyzed taking into account the existing data from Betrawati station. The discharge in the river is contributed from Langtang Khola, Bhote Koshi Nadi, Chilime, Mailung Khola and some small tributaries and springs on left and right banks of the river. While Annex 2 correlates historical flood flow records with water discharge level and gauge height, Annex 3 depicts cross-sectional outputs and its parameters 39 kilometers downstream of the dam.

Maximum flood at Betrawati from the DHM historical record states that from 1967 until 2016, the discharge level was 2020 in the year 1996 (4.55 meter depth), $4^{3}70$ m3/s in the year 2016 (5.5 meter depth). The instantaneous maximum flood data at Betrawati (DHM station number 477) has been taken for flood frequency analysis. According to the Gumbel extreme value distribution, the flood magnitude of 4020.63 m^3/s is approximately 10000 return year flood period as shown in figure below. For this study, data from 1967 to 2010 (44 years) has been considered (Annex 2a). As per the hydrological practice, it is not wise to estimate the return year flood beyond 100 years from 44 years of data. But for this study, there is no other alternative in the absence of hydrological data.

Figure 8: Average monthly flow at Intake

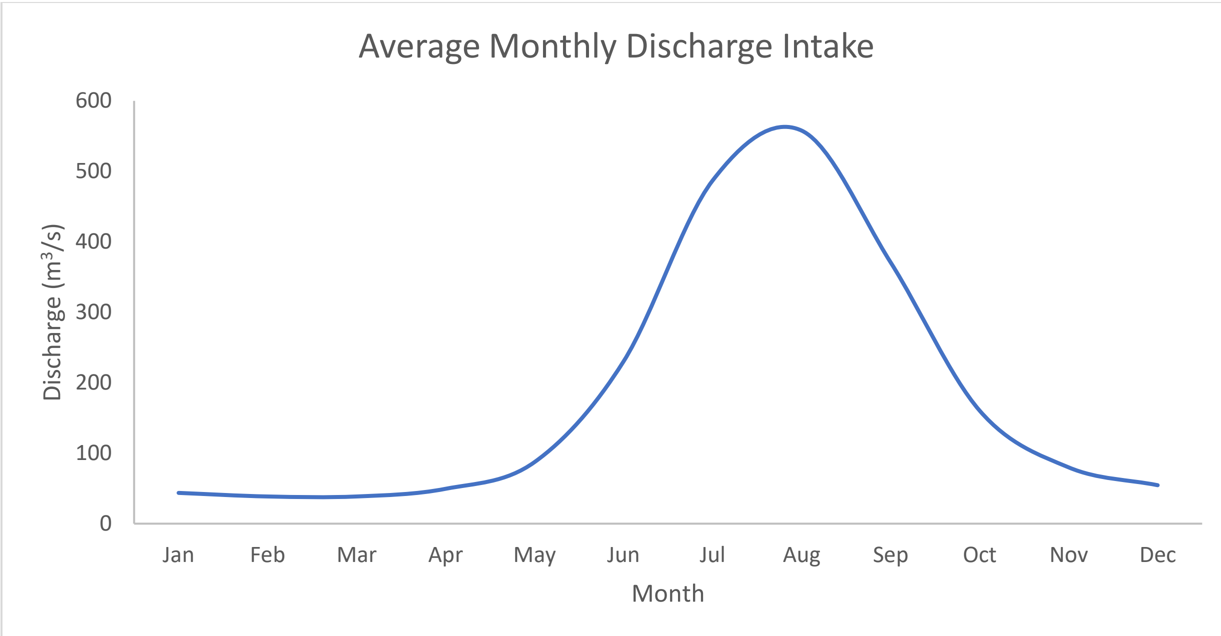
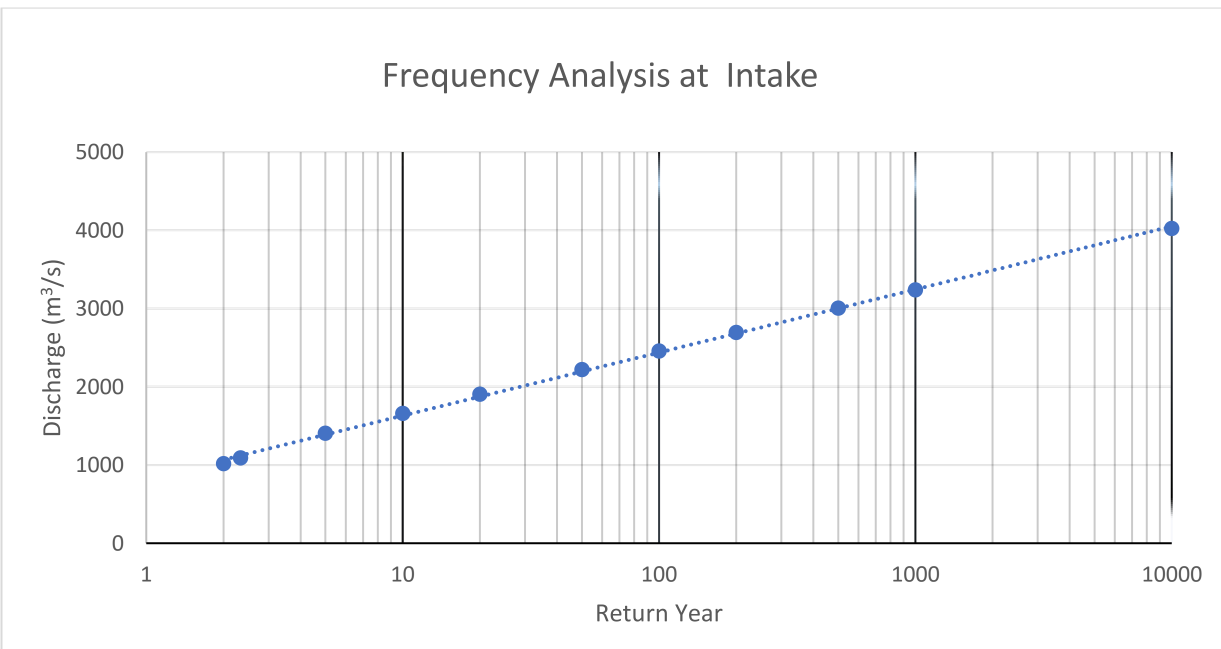


Figure 9: Flood frequency analysis at Damsite



3.7.4 Preparation of inundation map

The flood inundation map was developed for a section of Trishuli river. For this work, the HEC-RAS was used to calculate water-surface profiles; ArcGIS was used for GIS data processing. The HEC-GeoRAS for ArcGIS was used to provide the interface between the systems. HEC-GeoRAS is an ArcGIS extension specifically designed to process geospatial data for use with HEC-RAS.

The extension allows users to create an HEC-RAS import file containing geometric attribute data from an existing Digital Terrain Model (DTM) and complementary data sets. HEC-GeoRAS automates the extraction of spatial parameters for HEC-RAS input, primarily the three-dimensional (3D) stream network and the 3D cross-section definition. Results exported from HECRAS are also processed in HEC-GeoRAS. The general procedure adopted for inundation modelling consists basically of five steps: (a) preparation of terrain (DEM or TIN) in ArcGIS; (b) HEC-GeoRAS for pre-processing to generate a HEC-RAS import file; (c) running of HEC-RAS to calculate water-surface profiles; (d) post-processing of HEC-RAS results; and (e) floodplain mapping.

The inundation map (Figure 12) provides a description of the areal extent of flooding which would be produced by the dam break flood. It also identifies zones of high velocity flow and depict inundation for representative cross-sections of the channel. The selected flood generating factors such as average annual rainfall, soil map, elevation, slope, drainage density, and land use were rasterized and classified in raster format and then weighted overlay using ArcGIS 10.1 to generate flood hazard map (below). The inundation map illustrates downstream areas vulnerable to inundation by dam break flood. The map has computed maximum flood elevation at each original or interpolated cross-section available up to 39 km d/s of the dam. In case of dam break, the overall scenario is that there being no settlement areas between damsite and powerhouse area, no effect of flood in the reach but a few settlements immediately south of powerhouse location and agricultural field and settlement area below powerhouse are vulnerable to flooding. From the maximum water depth level of 11.9 meter during floods in Trishuli Reach as given in Table 11, the inundation map has been prepared for worst flow condition only, which is of prime interest and importance. Corresponding longitudinal cross section profiles of various stations and its parameters is shown in Annex 3.

However, with the increase in population at the emerging places and the market areas such as Mailung, and the downstream areas like Kalyanpur, Pahiro Besi, Betrawati, more people may be at risk in the event of dam break. The study indicates that due to hard topography in the UT1 reach people are not involved in the agricultural activities but due to emerging market places they might be at risk. But the people downstream from the powerhouse may be at risk due to intensification of agricultural activities. With the opening of four lane Trishuli-Syafrubeshi Highway (a project of national pride directly linking China's Kerung Border with the rest of Nepal), there is high possibility of rapid population growth because of livelihood, employment, educational and tourism opportunities thereby putting the ecological integrity at high risk. In addition, occurrence of occasional natural disasters like floods and landslides force people to migrate from their original place to other potential areas for livelihood. Due to different project opportunities, people migrate to new destinations and reside there. In the power house area, there does not exist any vulnerability as the project has duly considered this factor. In determining the downstream hazard classification, three principal considerations may be made – potential loss of human life; potential magnitude of property damage and corresponding economic loss and the potential environmental damage. The potential for loss of life is the primary factor in determining the downstream hazard classification.

The inundation map presented below in Figure 12 thoroughly considers dam break flood right from the dam site located in Haku VDC up to powerhouse and downstream to Betrawati confluence with the assumption of rectangular dam break discharge at 3059 m^3/s. The inundation map provides a description of the areal extent of flooding which would be produced by the dam break flood. It also identifies zones of high velocity flow and depict inundation for representative cross-sections of the channel. This is standard output of many flood routing models and inundation map has been developed utilizing cross-section and flood height data.

Several cross sections were placed at representative locations to describe the change in geometry (such as discharge, slope, velocity and roughness) along the Trishuli river downstream of the dam stretching over 39 km south-west from the dam site.

The Flood Forecasting Section of the Department of Hydrology and Meteorology has defined the warning level as the flood flow that just passes over the river bank, but does not affect the nearby settlements. It is the level of flow at bank full stage of a river. The danger level is that level of flow at which the flood water rises above the main stream channel and enters the settlements affecting people and their property but the depth of inundation remains within one meter.

Figure below presents the x-y-z perspective plot of the geometric features. Altogether, 195 cross-sections were generated from SRTM DEM. The detailed parameters of cross-section outputs are presented in Annex 2. The beginning point is the intake of the hydropower at Haku VDC and the end is about 12 kilometers downstream at Mailung upstream of the confluence of Mailung river of Rasuwa district.

Figure 10: Real time water level at Betrawati

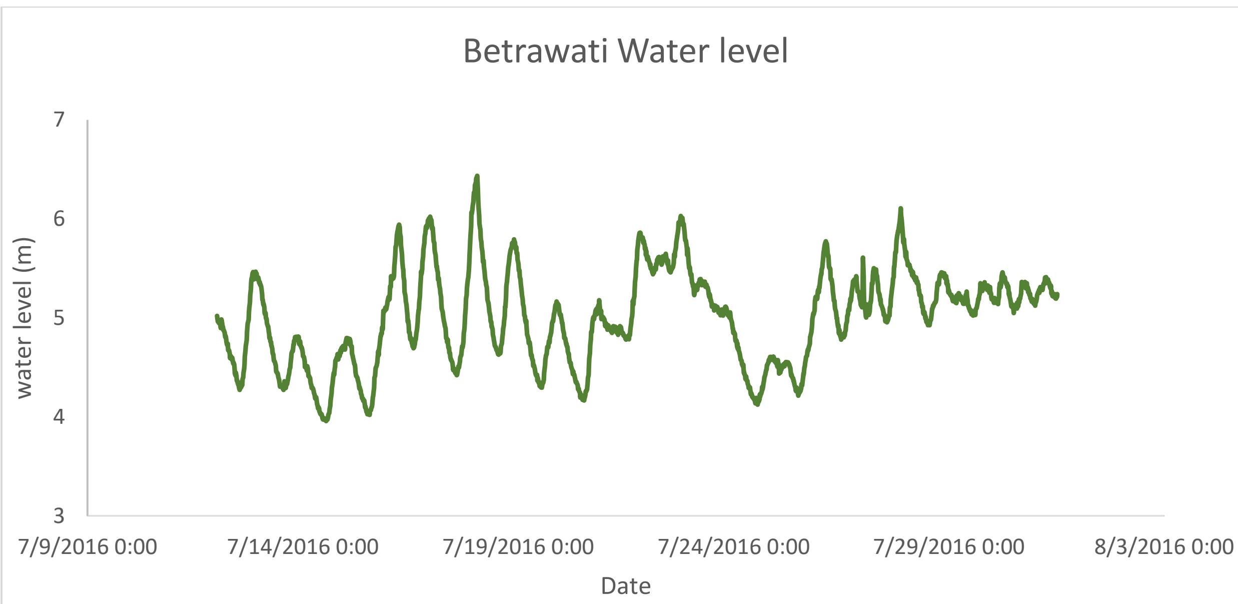
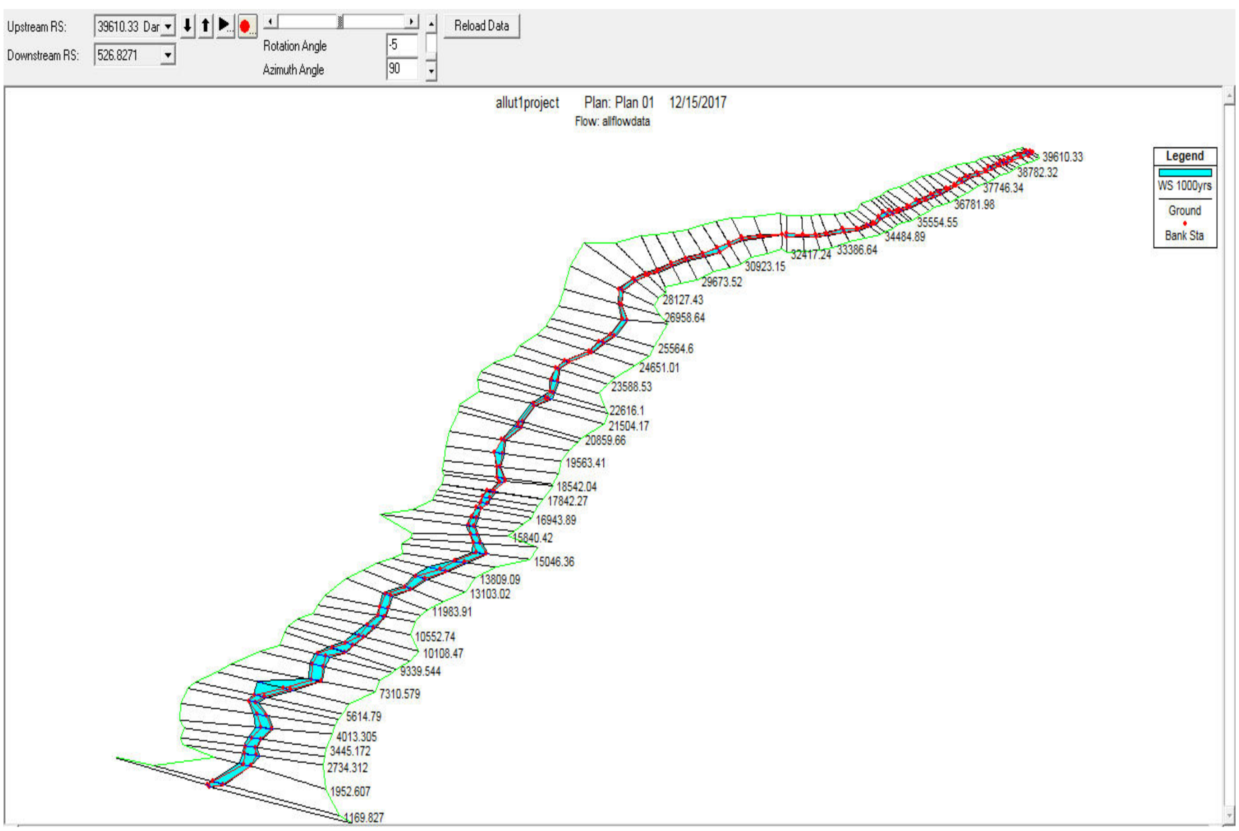


Table 11: Maximum water level during flood in near Betrawati Bridge

Plan:	One plan Trishuli	UT RS: 17842.27		Profile:	1000yrs
E.G.Elev (m)	644.42	Element	Left OB	Channel	Right OB
Vel Head (m)	2.18	Wt. n-Val	0.5	0.4	0.45
W.S. Elev (m)	642.24	Reach Len. (m)	6	6	6
Crit W.S. (m)	639.61	Flow Area (m^2)	29.16	439.23	28.31
E.G.Slope (m/m)	0.334679	Area (m^2)	29.16	439.23	28.31
Q Total (m^3/s)	3059	Flow (m^3/s)	62.23	2929.36	67.41

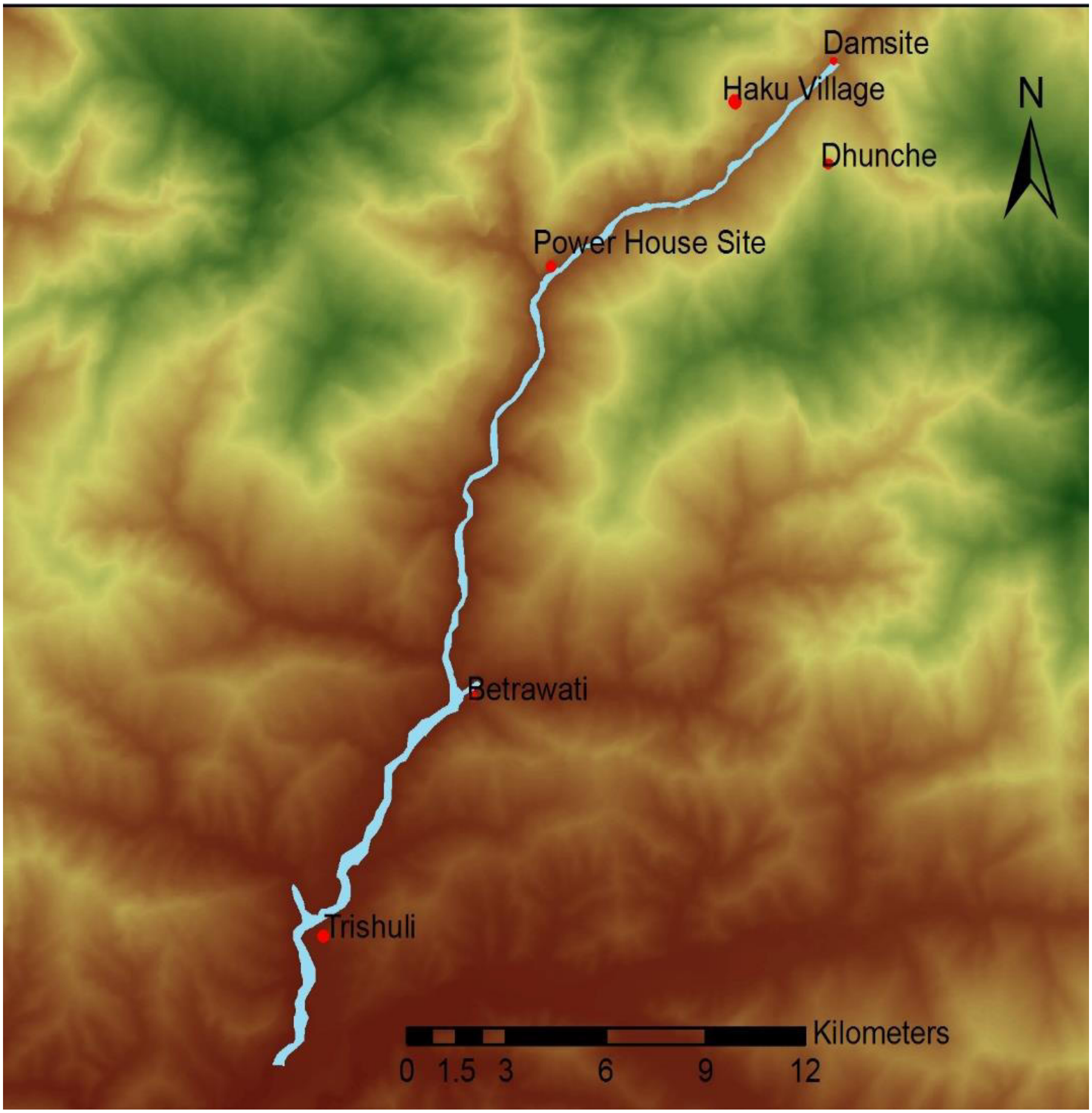
Top Width (m)	57.71	Top Width (m)	10	38.17	9.54
Vel Total (m/s)	6.16	Avg. Vel (m/s)	2.13	6.67	2.38
Max Chl Dpth (m)	17.08	Hydr. Depth (m)	2.92	11.51	2.97
Conv. Total (m^3/s)	5287.7	Conv. (m^3/s)	107.6	5063.6	116.5
Length Wtd. (m)	6	Wetted Per. (m)	11.64	44.36	11.23
Min Ch CL (m)	625.16	Shear (N/m^2)	8222.07	32499.58	8271.52
Alpha	1.13	Stream Power (N/ms)	17547.64	216748.60	19693.21
Frctn Loss (m)	0.07	Cum Volume (1000 m^3)	2617.92	43193.77	4441.09
C & E Loss (m)	0.64	Cum SA (1000m^2)	724.96	3486.20	1079.11

Figure 11: Longitudinal profile of Trishuli River downstream of dam along with chainage of river cross sections as per HEC-RAS model



As a result, warning and danger levels have been identified by analyzing the flood inundation scenario for a range of flow boundary conditions. It seems that the flow near 1900 cumec in Intake is more than a 25-year return year flood. Generally, a 5 to 10-year return year flood is a warning level flood in the mountains and 10 to 50 years flood is a danger level flood. It is on basis that even if there is no inundation but bank cutting and slope failures would be the consequence with more than 3 m/s flood velocity. Based on the above profile, it is inferred that about the areas below the power house such as Pokhari, Kaichaltar, Betrawati, Ramghat settlement areas near the river bank are vulnerable to flood. In general, most of the habitations all along the downstream areas well above the inundating boundary. The study suggests to install metaled flood warning signages at different locations downstream of the powerhouse.

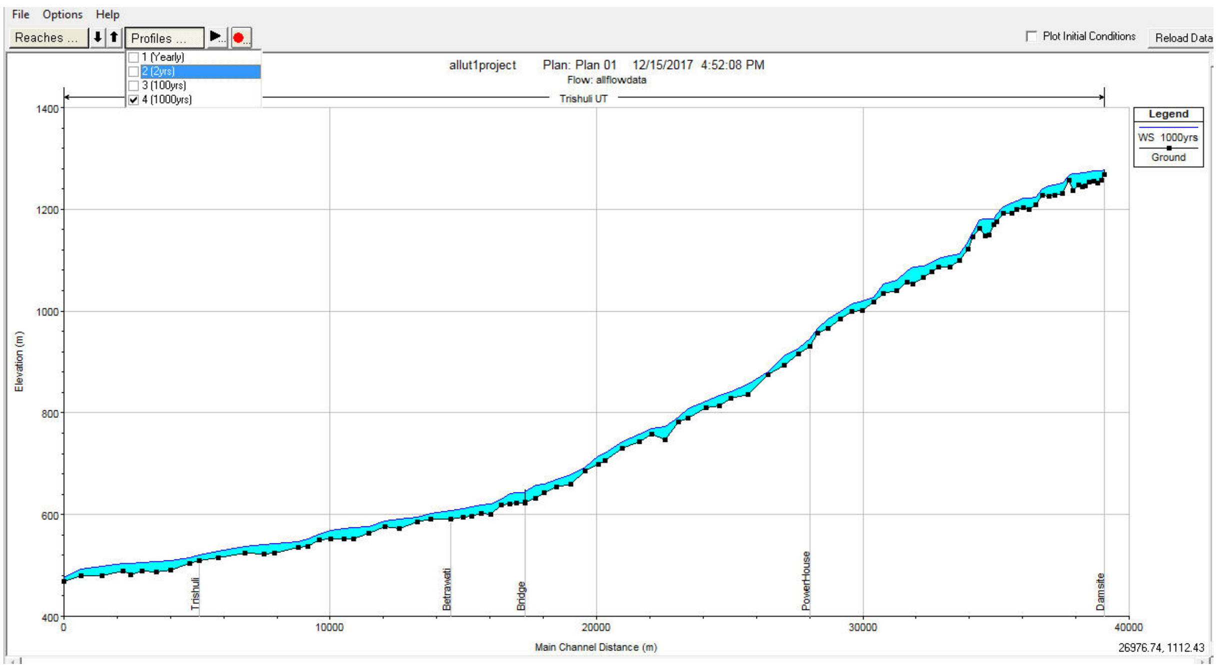
Figure 12: Flood inundation map downstream of the dam



3.7.5 Impacts on downstream of dam in case of dam break

A water level profile has been plotted for dam break from Dam axis in Haku VDC up to 39 km downstream to the confluence bordering Betrawati VDC of Rasuwa district and Nuwakot district along the Trishuli River to Trishuli Bazar (Figure 13). The HEC-RAS modelling indicates that the water velocity at the breach point just below the dam is 6.45 meter per second within the bank. The depth of water at the point of breach just below the dam is 18 meter as it reduces as it flows downstream reaching up to 11 meter depth after crossing 20 kilometer from the dam site. Water surface cross section profile outputs for dam break conditions of downstream stretch from dam site to 39 kilometer downstream up to Nuwakot are provided in Annex 3.

Figure 13: Water surface elevation variable profile from Dam to Trishuli



3.7.6 Results of analysis

The study has identified that immediately below the dam, maximum flow will occur immediately after the start of breach. Hence, high alert needs to be maintained for downstream vulnerable areas after the flood water reaches Mailung. Even as most of downstream inhabitations are above the inundating boundary at present, human settlements may increase in the inundation area in future or people's movement along the riverside could increase for fishing or for some other religious/cultural beliefs. It is to be noted here that thousands of Hindu devotees throng to the Betrawati confluence of Uttargaya near Betrawati bridge during mid-December *(Pushe Aunshi)* to offer homage to the departed soul. Again, this area is also presumed to be a hub for the anticipated railways connecting Kerung to Pokhara and Lumbini, which is most likely to increase human settlements adjoining the Trishuli river. It is, therefore, necessary to target the entire downstream VDCs and city areas foreseeing the population growth in future.

Hence, the result of two-dimensional mathematical modelling analysis has pointed out a remote possibility of concrete dam failure in the proposed UT1 HEP, which is being built with highest technical standards and adequate quality control. It also states that the monoliths having the least resistance to withstand the unforeseen loading combinations may give way, which in turn, provides relief and prevents failure of other monoliths. Under such a situation, the discharge and water depth will be much lesser than those determined from the study. This calls for the need to carry out routine surveillance activities at the dam site with additional surveillance during any flood events. Any sign of discrepancy needs to be immediately reported to the dam site in-charge.

3.7.7 Limitations

The uncertainties associated with dam break parameters, specially breach width, breach depth and breach development time may cause uncertainty in flood peak and arrival times. Further, the high velocity flows associated with dam break floods, especially immediately after the dam which rises to as high as 14 meter per second, can cause significant scour of channels. This enlargement in channel cross-section is neglected since the equations for sediment transport, sediment continuity, dynamic bed form friction, etc. are not included in the governing equations. The narrow channels with minimal flood plains are subject to over-estimation of water elevation due to significant channel degradation. The dam breach floods create a large amount of transported debris, which may accumulate at very narrow cross sections, resulting in water level variation at downstream locations.

This aspect has been neglected due to limitations in modelling of such complicated physical process. Accounting for topography and assumptions made regarding roughness co-efficient, flood inflows, dam break parameters, etc. which have been used to develop the inundation maps, the limits of flooding and flood wave travel time may not reflect the exact situation and shall, therefore, be used as a guideline to take warning, evacuation and emergency measures. The actual area of inundation would depend on the actual flow condition and failure phenomena and may vary, to some extent, from the limits shown on the inundation map.

3.7.8 Conclusion

The magnitude of the simulated outflow hydrograph is 3059 cumec corresponding to maximum stage elevation 1277 masl at 0 km. Flood height at the point of breach in dam site is 11.5 meter and after travel time of flood, its height is 8 meter from the river surface which is 4 meter below the bridge, with the bridge being 22 km downstream of the damsite. Considering the bank cutting and slope failure due to high velocity floods, safe location stands at 20 meter higher from the bridge. This river water traverses about 22 km downstream near Betrawati wherein the water flow slope becomes reduced. From the water level rise of 11 meter, the inundation map has been prepared as the flood velocity is 6 meter per second.

As measured flood data by the Department of Hydrology and Meteorology in August 2016, the rainfall-induced flood level in Betrawati was 5.5 m with the discharge of 4370 cumec which is greater than 1000 years flood. Hence, taking this into consideration, settlements adjoining the Trishuli river is expected to be inundated which calls for effective disaster preparedness.

3.8 Evaluation of potential emergencies

If during visual inspection or review of instrumentation data, the site-in-charge identifies a potential emergency, it is vital that NWEDC immediately undertakes an assessment of the identified problem. It is essential to ensure that the responsible persons undertaking the assessment have appropriate knowledge and experience relating to the identified problem. Swift and appropriate evaluation of a potential emergency will provide an opportunity to carry out preventative actions to reduce the likelihood of the situation deteriorating into an emergency situation.

The evaluation procedure must be clearly defined and should include analyzing the severity of the existing situation and determining the probable and worse case development of the situation. It should also include recommendations as to the appropriate preventative actions which can be undertaken, a likely timeframe and at what stage declaring an emergency situation is likely to be required. Preventative actions may be undertaken before full evaluation is complete, if required, but these are only to be undertaken on the instruction from the Engineer-In-Charge.

Additional resources such as stockpiling supplies and materials, aids, instructions and provisions for interpreting information and data should be put in place following the detailed design and construction stages. The location and availability of any stockpiled materials and supplies for emergency use should be identified and accurately recorded, including the quantity available. These stockpiles must remain for the use of a preventative action only, and should be regularly checked and maintained to ensure availability for immediate use.

The emergency planning for dam break scenario is devised on the basis of results of dam break analysis mainly the travel time of flood wave to various locations in the downstream stretch of the river. It is inferred from the dam break analysis that given the 8-meter height of dam, there is almost a zero possibility of dam break. However, the Disaster Management Plan suggests NWEDC to apply a high degree of alertness through timely disaster preparedness measures.

3.9 Dam Safety and Maintenance Manual

Based on the standard recommended guidelines for the safety inspection of dams, NWEDC shall prepare a manual for dam safety surveillance and monitoring aspects. This should be updated with the availability of instrumentation data and observation data with periodic review. The need for greater vigilance has to be emphasized during first reservoir impoundment and first few years of operation. The manual should also delve on the routine maintenance schedule of all hydro-mechanical and electrical instruments. It should be eloquent in respect of quantum of specific construction material needed for emergency repair along with delineation of the suitable locations for its stocking and also identify the much-needed machinery and equipment for executing emergency repair work and for accomplishing the evacuation plan.

3.10 Emergency Action Plan (EAP)

As indicated above, the dam safety programme includes the formation of an Emergency Action Plan (EAP) for the dam. An emergency is defined as a condition of serious nature which develops unexpectedly and endangers downstream property and human life and required immediate attention. EAP should include all potential indicators of likely failure of the dam, since the primary concern is for timely and reliable identification and evaluation of existing of potential emergency. This EAP presents warning and notification procedures to follow during the monsoon season in case of failure or potential failure of the dam. The objective is to provide timely warning to nearby residents and alert key personnel responsible for taking action in case of emergency.

3.10.1 Administration and procedural aspects

The administrative and procedural aspects of the Emergency Action Plan is outlined in the form of a flow chart (see notification flow chart in Chart 6) depicting the names and addresses of the responsible personnel of project proponent and the district administration. In the event that the failure is imminent or the failure has occurred or a potential emergency conditions is developing, the observer at the site is required to report it to the junior engineer who will report to the Head of the Department for their reporting to the Head of Project through a wireless system or by any available fastest communication system.

The Engineer-in-Charge is usually responsible for making cognizant with the developing situation to the Civil Administration. Each personnel are to acknowledge his/her responsibilities under the EAP in an appropriate format at a priority. The technical aspects of the EAP consist of preventive action to be taken with regards to the structural safety of the dam. The EAP is drawn at a priority for the regular inspection of the dam. For this purpose, providing an adequate and easy access to the dam site is a necessity. The dam, its sluices, overflows and non-overflow sections should be properly illuminated for effective operations during night time. They are required to inform the Engineer-in-Charge and the local administrative authorities. It is desirable if the downstream inhabitants are warned using siren, if available, so as to make them aware the likely imminent danger.

Areas from where the labour can be mobilized should be chalked out at a priority. In addition to these, public participation in the process of execution of the EAP may further help in amelioration of the adverse impacts of the likely disaster. For this, it is necessary that the public should be made aware of its responsibilities.

3.10.2 Preventive action

Once the likelihood of an emergency situation is suspected, action has to be initiated to prevent a failure. The point at which each situation reaches an emergency status shall be specified and at that stage the vigilance and surveillance shall be upgraded both in respect of time and level. At this stage, a thorough inspection of the dam should be carried out to locate any visible sign(s) of distress.

Engineers responsible for preventive action should identify sources of equipment needed for repair, materials, labour and expertise for use during an emergency. The amount and type of material required for emergency repairs should be determined for dam, depending upon its characteristics, design, construction history and past behaviour. It is desirable to stockpile suitable construction materials at appropriate sites. The anticipated need of equipment should be evaluated and if these are not available at the dam site, the exact location and availability of these equipment should be determined and specified. The sources/agencies must have necessary instructions for assistance during emergency. Due to the inherent uncertainties about their effectiveness, preventive actions should usually be carried out simultaneously with the appropriate notification on alert situation or a warning situation.

3.11 Evacuation Plan

Emergency Action Plan includes evacuation plans and procedures for implementation based on local needs. These could be:

- Demarcation/prioritization of areas to be evacuated;
- Notification procedures and evacuation instructions;
- Safe routes, transport and traffic control;
- Safe areas/shelters; and
- Functions and responsibilities of members of evacuation team.

Any precarious situation during floods will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure of flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the dam. It would normally include an order for evacuation of delineated inundation areas. The most vulnerable/submergence area in the downstream will be demarcated with the help of flood wave travel time analysis and accordingly would be planed the evacuation plan in inundation areas.

In the event of an earthquake, immediate information needs to be passed on to the District Administration Office in Rasuwa, security forces, warning stations, representatives of rural municipalities and people living near High Flood Level (HFL) mark asked to be ready for evacuation. Necessary action also needs to be taken to shift field staff to safer places. Thereafter, inspection of structures in the dam complex and other structures, especially over-ground structures such as portals and bridges need to be carried out for the assessment of any damage and make immediate decisions for remedial measures.

Chief of NWEDC's Personnel Department shall personally inspect school buildings, community halls, VDC health posts, etc. for temporarily accommodating the likely affected people. He shall organize essential requirements of people like water, food, etc. from the Corporation resources. In conjunction with the local administration, he shall coordinate with the district and rural municipality elected officials for making transport arrangements to safer areas. The safe route for evacuation shall be utilized as road, local footpath and aerial transportation in the flood affected area jointly with the security officials.

3.11.1 Evacuation Team

The evacuation team will comprise of following officials/representatives:

- Chief District Officer (CDO) or designated officer to immediately relocate people to places at higher elevation;
- Engineer-in-charge of the project;
- Superintendent of Police (SP) or his designated officer to maintain law and order;
- Chief Medical Officer (CMO) of Rasuwa district hospital to tackle morbidity of affected people;
- Head of the affected village/s to execute resettlement operations with the aid of district machinery and project proponents; and
- Sub-committees at village level.

The Engineer-in-Charge will be responsible for the entire operation including prompt determination of the flood situation time to time. Once the red alert is declared, the entire local state machinery will come into full swing and start evacuating people in inundation areas delineated in the inundation map. For successful execution, mock drills and demonstration exercise will be annually conducted. CDO is expected to monitor the entire operation.

3.12 Emergency action plan

Emergency identification and evaluation during construction and O&M stages

The emergency action plan includes emergency identification and evaluation matrix containing following items:

i. Listing of the conditions or events which could lead to or indicate an existing or potential emergency during construction and O&M stages of the project;
ii. Brief description of the means by which potential emergencies identified, including the data and information collection system, monitoring arrangements; and
iii. Designation of persons responsible for identifying and evaluating emergency.

Accordingly, emergency identification and response level matrix has been prepared for the construction stage of the project (Table 12).

Table 12: Types of emergencies/causes during construction stage

SN	Response Level	Heavy rock fall/ chimney formation during underground excavation	Hazardous gas during underground excavation	Explosive hazards	Hydrological event/ flooding	Abnormal instrument readings	Earthquake
	1	2	3	4	5	6	7
1.	Internal Alert Situation can be managed internally. Outside notification not required.	Heavy rock fall or formation of chimney in crown during underground excavation due to geological conditions. Safety measures should be adopted at site for safety of workers and equipment. EIC and contractor must be informed immediately about the occurrence of event. Medical team should rush to site for immediate attention. After preliminary examination/	Sudden encountering of hazardous gas/poisonous gas during underground excavation. Safety measures should be adopted for safety of workers. Level of gas should be measured immediately by safety team. De-fuming should be started by making the Ventilation system operative. EIC and Contractor must be informed immediately about the encountering of gas. Medical team along with protective equipment should rush to site for	Release of gas due to explosive stored underground or fainting of workers due to explosive gasses released after blast. Safety measures should be adopted for safety of workers. Level of gas should be measured immediately by safety team. De-fuming should be started by making ventilation system operative. EIC and contractor must be informed immediately about the event. Medical team along with protective equipment should rush to site for immediate attention of the workers. After preliminary examination/ first	Water level at G&D site start increasing indicating likely flooding of d/s area. Information of flood approaching should be passed to project authorities and contractor from G&D warning stations. Evacuation of workers working below flood level should start immediately to safe level at all sites. Machinery below flood level should be moved to safe level at all the sites. All alert stations should alert by blowing the hooters. Contact should be	In case instruments placed in the main civil structures of project show abnormal readings, the same would be critically examined jointly by the project and design department. After the analysis of abnormal readings, remedial measures to be taken shall be jointly decided by project and the design department	Earthquake less than or greater than DBE recorded; Various components of the project will be designed for earthquake conditions applicable to them. After the earthquake, the visual inspection of all components of project, especially over- ground structures like dam, portals Bridges, etc. will be carried out and instrumentation readings will also be taken and the same shall be intimated to the design department. Action should be taken as per the suggestion of the Design Department

SN	Response Level	Heavy rock fall/ chimney formation during underground excavation	Hazardous gas during underground excavation	Explosive hazards	Hydrological event/ flooding	Abnormal instrument readings	Earthquake
		first aid of workers, their evacuation should start	immediate attention of the workers. After preliminary examination/ first aid of workers, their evacuation should start. Treatment to the effective workers should be given in hospital.	aid of workers, their evacuation should start. Treatment to the effective workers should be given in hospital.	established with local G&D site for monitoring of flood.		

Chapter 4: Disaster monitoring and early warning system

4.1 Community-based disaster risk management

Community participation has been recognized as the additional element in disaster management necessary to reverse the trend of exponential increase in disaster occurrence of and loss from disasters and build a culture of safety. Whether a disaster is major or minor, it is project affected communities who suffer its adverse effects the most. The Disaster Management Plan needs to embrace community-based disaster risk management approach as this approach can transform vulnerable groups and communities to disaster resilient communities, which can withstand and recover from stresses and shocks from the natural disasters.

With the shifting of paradigms from reactive emergency management to disaster risk reduction, there is more stress on proactive pre-disaster interventions, which are usually categorized as prevention, mitigation and preparedness. The plan needs to involve local communities in developing solutions to disaster preparedness as by involving community members it not only increases the likelihood of increased action by communities to help prepare for disasters but also brings communities together to address issues collectively thus leading to a great probability of reducing damage, deaths and economic devastation in the affected communities.

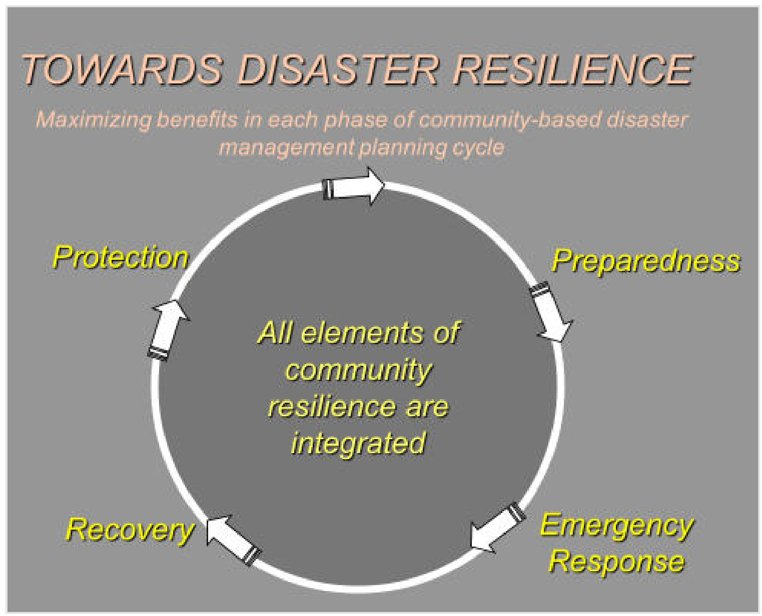


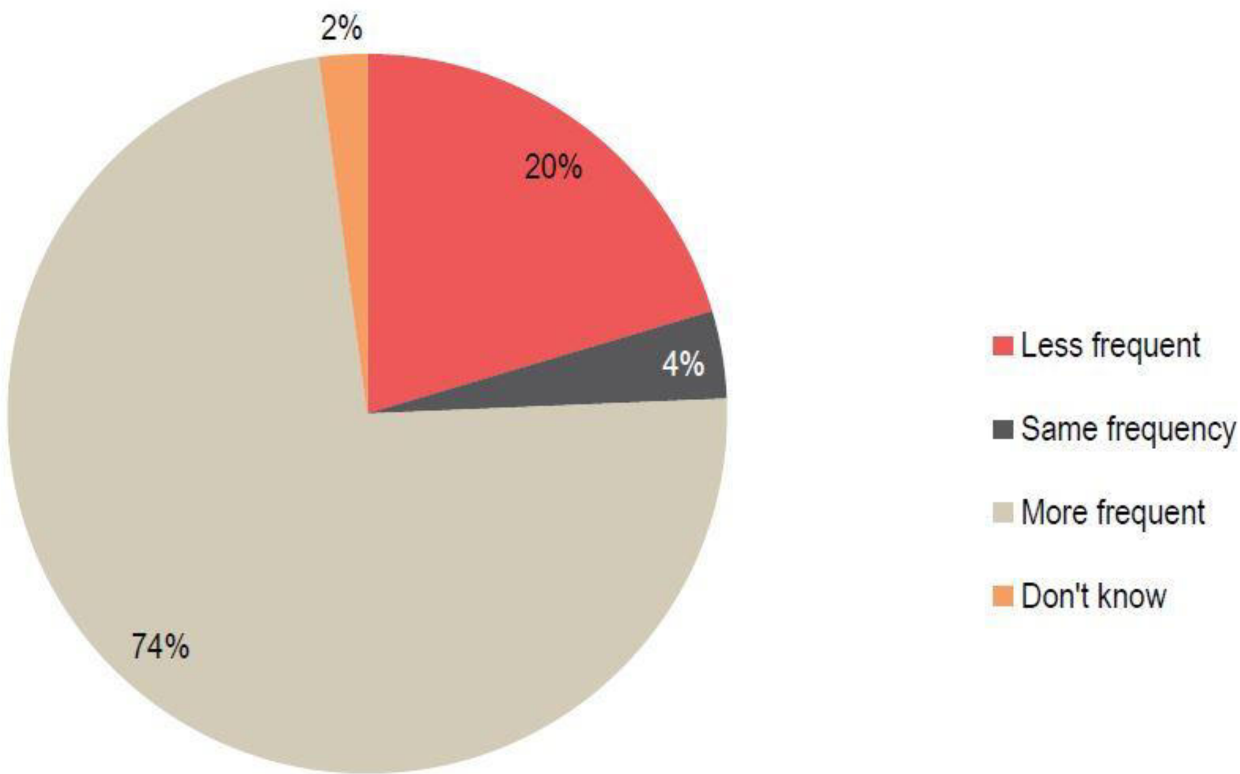
Chart 2: Key elements of community resilience

It is, therefore, important to empower project affected communities to systematically respond to disasters by building their capacity on disaster preparedness, which involves measures taken in anticipation of a disaster such as setting up the systems for early warning, coordination and networking, evacuation and emergency operations management and raising disaster education and awareness. Communities also need to be involved in search and rescue, immediate repair and restoration of critical facilities and utilities, conduct damage needs and capacity assessment, distribution of food and non-food relief assistance, rehabilitation and reconstruction (Chart 2).

Successful disaster risk reduction must be in place well before a disaster strikes. In other words, it is crucial to shift the focus away from merely responding to disasters, and to focus particularly on disaster prevention and preparedness activities. Similarly, DRR is not a single intervention, but a repeating cycle of adapted interventions. On this basis, DRR can be defined as: DRR= hazard multiplied by vulnerability reduction divided by capacity development.

During the community consultations undertaken in the project VDCs, people clearly stated which were the key hazards and were generally in agreement that they posed a serious problem and urgently needed addressing. This is perhaps unsurprising given that a large majority of respondents reported living through several natural disasters over the course of their lives. When asked if the main hazard in their community had changed in frequency over the past 30 years, 74% said it has become more frequent, 20% said it has become less frequent, 4% said it has remained the same, and 2% said they did not know (see Figure 12).

Figure 12: Percentage of individuals reporting increase in hazard frequency

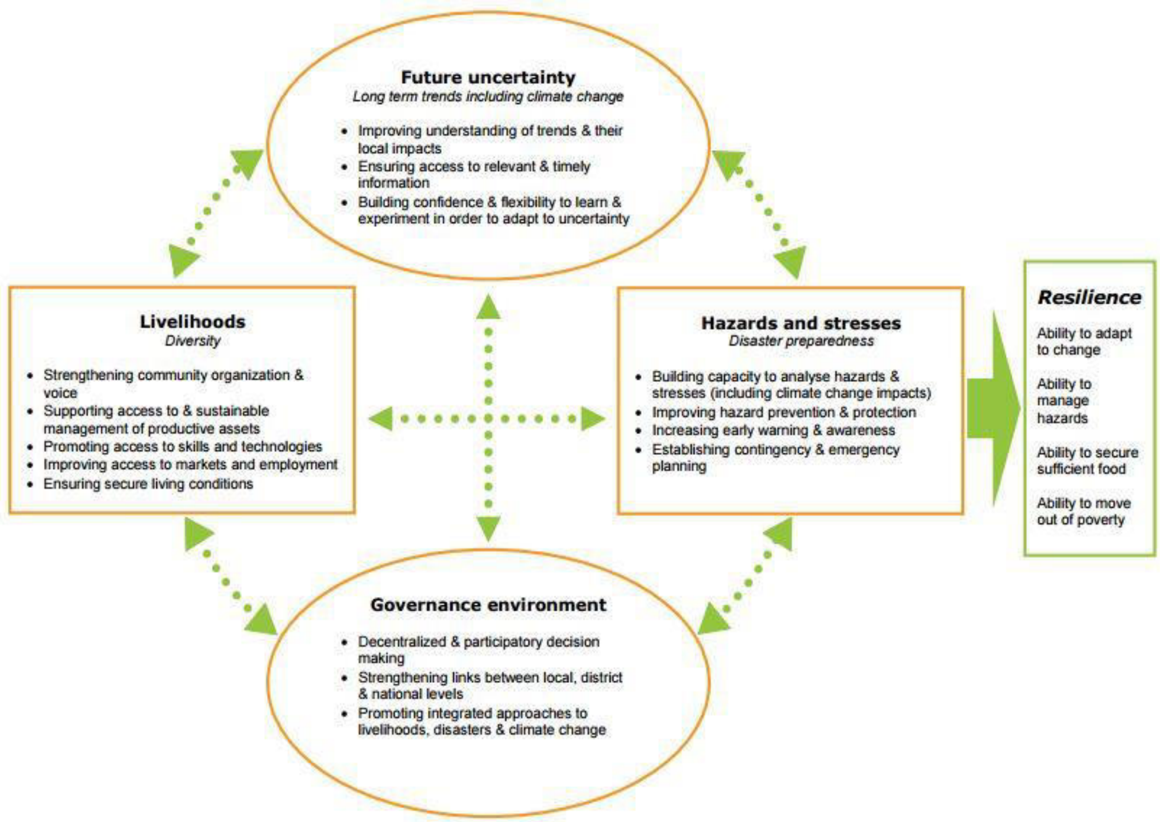


One of the core objectives of the Disaster Management Plan is to build resilience of downstream communities by reducing their vulnerability and increasing ability to withstand and minimize the effects of disaster and complex emergencies. Hence, the plan needs to integrate DRR into the local livelihood activities which will ensure that the communities and households will internalize hazard and risk analysis, consider risk and vulnerability as well as opportunities while determining their livelihood strategies. It is only by adopting this approach (Chart 3), NWEDC can address the root causes of disasters, namely reducing the overall vulnerability, increasing capacity and thus strengthening the resilience of vulnerable communities. In order to fulfill this objective, NWEDC needs to give priority to prevent the cause or impact of a disaster rather than to provide emergency relief; give thrust on the development of initiatives that increase preparedness and reduce the dependency on relief, give priority to organized local support through community-wide preparedness interventions and promote permanent measures rather than only to temporary measures.

In UT-1 HEP, two inter-related strands of work are central to building community resilience. Firstly, livelihoods are strengthened by working with the project affected communities and forging links to service providers to build capacity and voice, and support access to assets, skills, technologies and markets for enhanced production, income and security. Secondly, hazards and stresses are addressed through disaster-preparedness measures, including hazard analysis, prevention, protection, early warning and contingency planning. As a starting point, NWEDC needs to strengthen project affected communities' knowledge and capacity to protect their life and valuable properties when disasters strike. It includes enhancing people's knowledge and skills and resources on DRR preparedness measures through livelihood improvement interventions. NWEDC also needs to ensure communication and coordination with Trishuli 3A HEP (60 MW) and Trishuli B (42 MW) being constructed downstream of the powerhouse area so as to establish connectivity and mobilize resources for disaster preparedness.

In dealing with disasters, a set of sequential actions are required – what actions are to be taken at normal time, what actions are to be taken prior to the commencement of disaster season, what actions are to be taken on receipt of warning, what actions are to be taken on the occurrence of disaster, and what actions are to be taken for post-disaster activities. Annex 5 sheds light on the prescribed doable actions in the form of the checklist.

Chart 3: Proposed vulnerability to resilience (V2R) framework

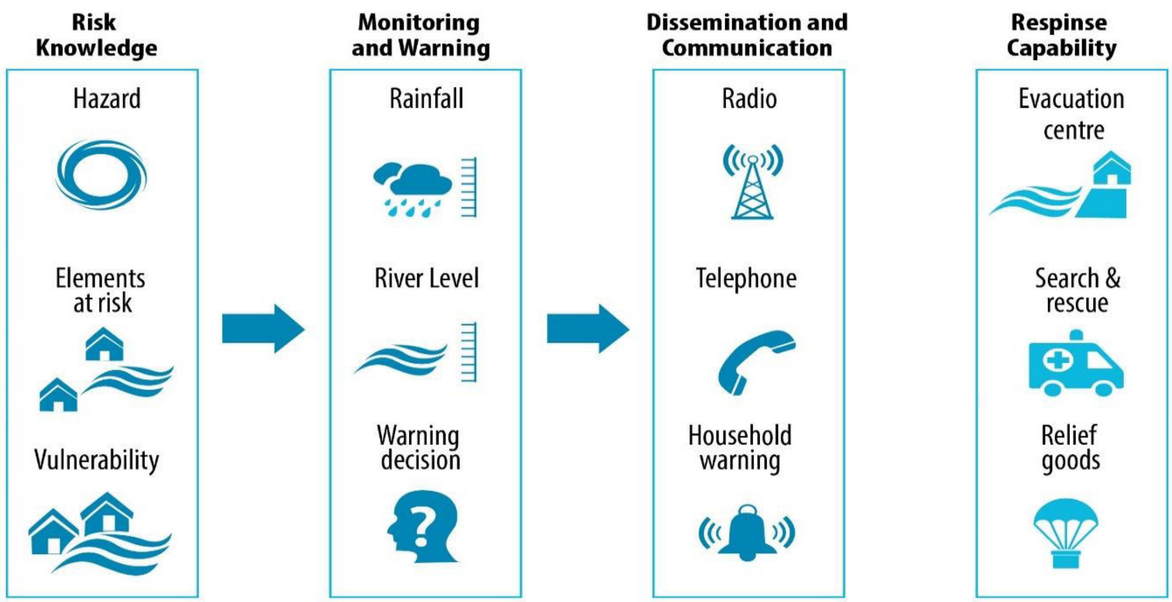


4.2 Installation of Early Warning System (EWS)

Early Warning System (EWS) has been increasingly recognized as a critical tool for saving lives and livelihoods and there are increasingly more investments to support such systems. EWS is a process in which community risk knowledge is acquired and disseminated to the at-risk communities prior to the disasters strike. In fact, EWS includes a chain of concerns, namely, understanding and mapping the hazard, monitoring and forecasting impending events; processing and disseminating understandable warnings, and undertaking appropriate and timely actions in response to the warnings.

The ‘people-centred’ elements require many systematic approaches and diverse activities such as identifying target population, especially vulnerable and disadvantaged groups and interacting with them to determine needs and capacities; conducting community meetings and involving communities in exploring and mapping their risks and planning their responses; generating public information tailored to target groups; developing formal mechanisms for community representatives to monitor and oversee warning system design; providing training who operate the warning system; and providing exercises and simulations to enable people to experience and practice warning interpretation and responses. A complete and effective EWS comprises four inter-related elements: risk knowledge, monitoring and warning service, dissemination and communication, and response capability (Chart 4).

Chart 4: Key elements of EWS



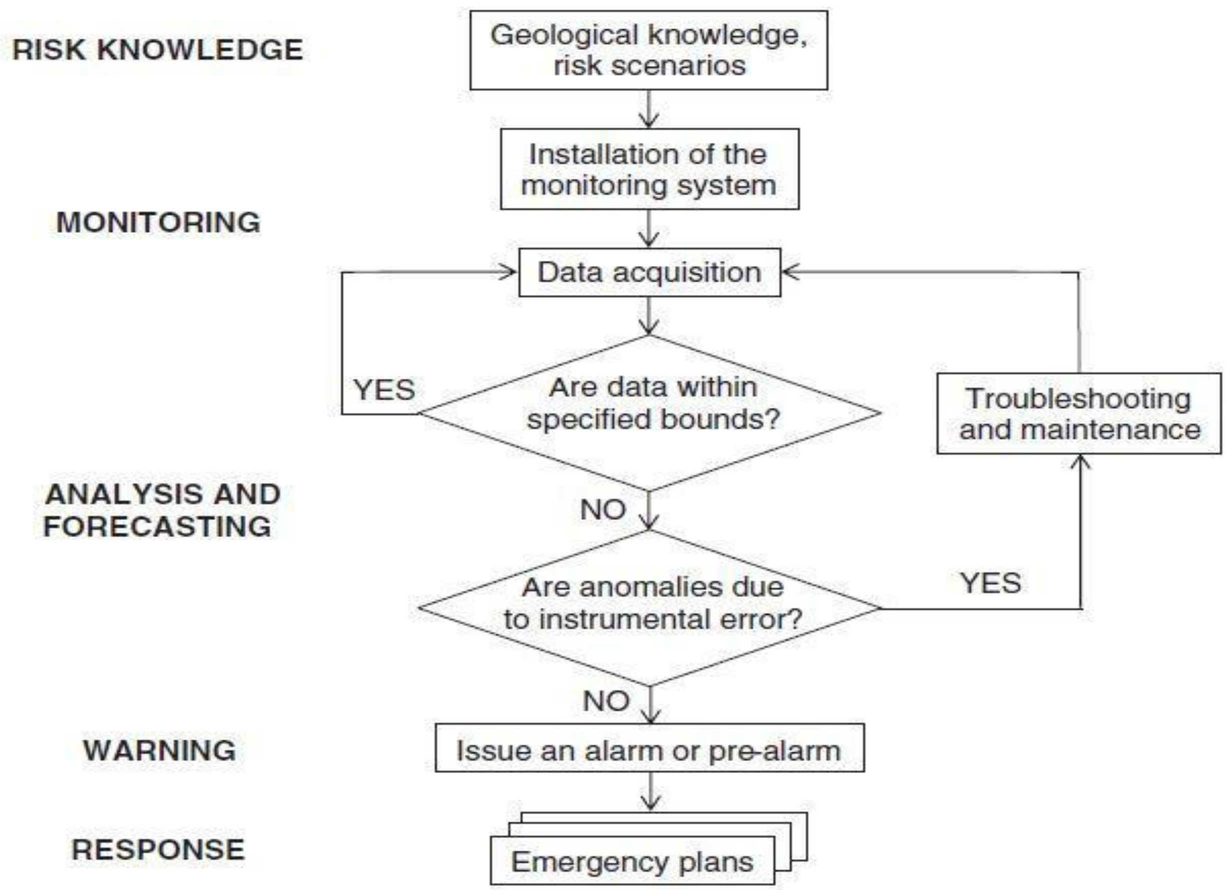
Identification of potentially dangerous natural disaster and recognition of risks associated with them has become a priority task. This calls for the implementation of appropriate measures to reduce the potential risks. Measures include monitoring to provide an early indication of changes; early warning systems to provide downstream residents time to take avoidance action; and mitigation measures, to physically change the situation and thus reduce the risk.

An intensive warning system is needed during short periods even when the UT-1 HEP construction work is underway or for other reasons when a significant risk is identified. It must be remembered here that in 1998, the Government of Nepal had installed a fully automated early warning system at Tsho Rolpa and Tamakoshi valley intended to warn people living in downstream areas in the case of a GLOF event, and consisted of a GLOF sensing and warning system. Police and Army camps were also established to protect the system. The sensors would detect the occurrence of a GLOF and transmit relevant information to the transmitter station thus setting in motion the warning process. The warning would sound to alert the local people downstream.

However, four years after its installation, the early warning system was no longer operating despite the fact that it was a robust system commissioned with the latest technology. Lack of participation by the local communities appears to have led to the system being ignored and then destroyed, with components being taken to use for other purposes locally. The tendency towards ignoring the importance of early warning is a cause of concern and NWEDC must ensure local ownership through people's active participation in the initiative.

In the context of UT-1 HEP, EWS needs to be set up primarily to avoid or reduce the impact of flash floods by taking necessary preparedness measures and act appropriately in sufficient time. Heavy rainfall at upstream will have a direct impact on downstream communities. Downstream communities will only be able to get timely early warning information when this can be provided from upstream communities or observers. Hence, it is essential to link both upstream and downstream communities for effective operation of EWS (Figure 14).

Figure 14: Flow chart of activities of a generic early warning system



The establishment of EWS and associated preparedness and response systems is an important element of the Disaster Management Plan. Based on the discussion with the Department of Hydrology and Meteorology and the district administration for the upstream areas of the dam, and after the reconnaissance survey conducted from the dam site to 39 kilometers downstream, the plan has identified two strategic sites—Mailung Bazar and Betrawati for the installation of EWS and water alarm system/water level gauge signage:

The first station that should be able to receive an early warning of flash flood is at the powerhouse site. The data collection platform will log data received and transmit the data using satellite, CDMA and GSM to the central server. When a threshold is crossed, the station will immediately transmit an alert message via the satellite or cellular network to the Central Server. For alerting communities, the server communicates with the early warning systems and trigger a voice message. Both the warning stations shall have adequate communication equipment, qualified staff to supervise the occurrence of any disaster and staff to gauge the level of discharge. The warning stations will also have power backup facility like inverters and DG sets for continuous uninterrupted power supplies in case of any emergency. The discharge reading at every one-hour interval shall be conveyed to the dam site and frequency may increase in case of exigencies.

In case of flash flood, warning message shall be communicated from dam control room to all the construction sites where man and machinery is deployed below the High Flood Level (HFL) during construction stage and to the powerhouse during O&M stage. Message regarding the same shall be simultaneously conveyed from dam control room to site staff at dam site to immediately implement contingency plan. Message regarding the raise of water level in Trishuli River and inferred inundation shall be communicated from dam control room to the powerhouse and district administration at Rasuwa. Persons in the vicinity of river shall be informed to move away to the safer locations before releasing excess flood water from the dam during O&M stage. Sounding of hooter/siren shall be made from dam control room at least three times in an interval of half an hour before releasing excess flood water in the downstream of the dam during O&M stage. In case of major flood anticipated, all possible movable property, instruments, etc. shall be shifted to safer place. After dogging of radial gates, the dam site shall also be vacated after fulfilling compliance.

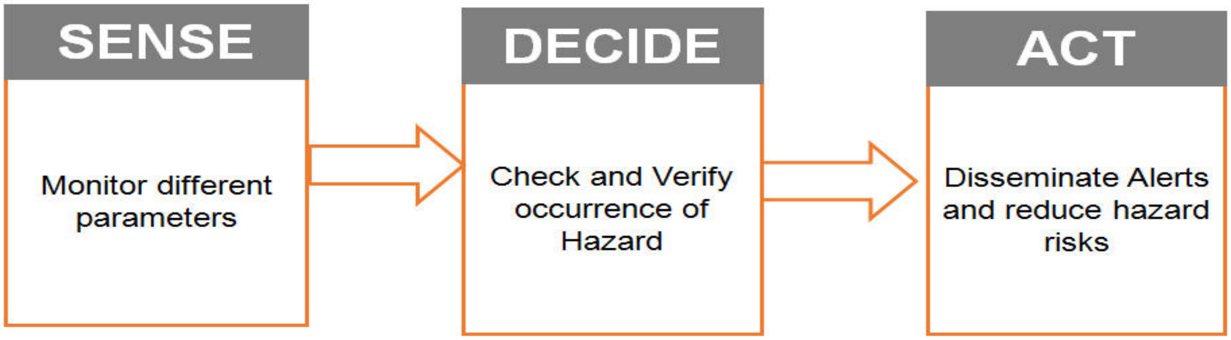
A total of two EWS needs to be set up in Mailung and Betrawati in order to help mitigate the disastrous effects of flooding, largely from dam break. The system is a non-structural disaster mitigation measure that encompasses hydrological monitoring (river stage observation), information collection, flood warnings based on river stage and rate of water level rise.

4.3 System architecture for networking and seamless integration of EWS

Climate change has made considerable impacts on the glacier lifecycle in recent decades and worldwide receding of mountain glaciers is one of the most reliable evidences. In high mountainous terrains, with melting of glaciers, the risk of glacial related hazard increases. Besides glaciers, there are other risks involved in the mountain terrain such as heavy rainfall induced flash floods, landslide induced natural damming, etc.

The upper basin of the Trishuli river lies beyond the territory of Nepal which cannot be monitored, at least for now. The Bhotekoshi river flood of July 2016, induced by GLOF has made us aware of the dangers of cross-border floods. Similarly, the Seti flash flood of 5 May 2012 has proved us the dangers of natural damming of rivers due to avalanches and landslides. However, it is not within human domain to stop natural catastrophe but we can develop an approach towards disaster preparedness. Such approach has the potential to greatly reduce loss of life and property. The most effective way to mitigate the risk of natural disasters is to ensure timely dissemination of warning to downstream vulnerable communities. One dollar invested in disaster preparedness can prevent seven dollars’ worth of disaster-related economic losses.

The basic concept of any early warning system can be explained by three simple steps.



Sense
The easiest way to sense the occurrence of flood is to sense the water level of the river. There are various sensors designed to monitor water level of the river. In addition to monitoring water level, it is also possible to check the presence of water level at a pre-set threshold value. Values from the sensors has to be transmitted through a communication channel that can relay the real-time data to a central server where the machine and human can make a decision. Apart from monitoring water level of the river, it is also important to monitor precipitation in a particular location. It is important to understand the rise in water level due to precipitation to rule out other threats.

Decide
Real time or near real time data of water level and precipitation helps to decide occurrence of actual hazard. Upstream communities have very short lead time, hence need immediate alerts. Whereas the downstream communities having a long lead time, provides enough time for human verification of actual hazard before the alerts are generated. Hence the central server receiving data from all the stations should have the capability of making decisions automatically, or should have human assisted decision making so that the user can approve or cancel the alerts.

Act
After a hazard has been verified, the early warning system needs to alert the vulnerable communities. There are various methods that can be used, but the most effective methods are huge voice speakers. A huge voice speaker is similar to siren systems with the capability of playing multiple pre-recorded voice messages. Being able to play different messages, it is useful for multi-hazards. The same infrastructure can be used for flood warning, landslide warning, earthquake warning, fire, etc.

4.3.1 Audio alerting system

An audio alerting system is used to alert the communities about a hazard. The Audio Alerting System is digitally connected to the central server and will get triggered centrally. The audio alerting system consists of the following components:

- Remote Terminal Unit with audio playing capability
- Communication Modem
- Efficient Amplifier
- Horn Speakers
- Power supply with battery backup
    - Solar Panel

    - Solar Charge Controller
    - Rechargeable Battery
- Protection Housing

Besides audio playback, the audio alerting system also has capabilities to log and transmit the station of the system. Such as battery voltage, solar panel voltage, signal strengths, etc. This way, the remote engineer can monitor the health status of the system.

4.4 Specification of equipment in Early Warning Station

4.4.1 Radar level sensor

A radar level sensor will be used to monitor the water level of the river. The radar level sensor is chosen such that the sensor will reside at a height and will not be damaged even during a flash flood event.

Specification:

- Measuring range: 0.8 to 40m
- Measuring accuracy: ∓2mm
- Beam angle of antenna: 8°
- Power supply: 12V typical
- Operational temperature: -25°C to + 60°C
- Protection: IP 67 (submersion depth max 1m)

4.4.2 Water content sensor

Water content sensor shall be placed at locations to detect the river widening or change in water level. The water content sensor will be placed at a height which defines the flood threshold. The water content sensor should use UV protected rugged cable that is rugged enough to withstand extreme weather and debris flow in the river.

4.4.3 Wireless remote terminal unit

Since the DCP's will be placed above the river gorges on a higher altitude possibly around human settlement. A wireless Remote Terminal Unit will be required to transmit the data from the RLS and Water Content Sensors to the DCP.

Technical specifications:

- Wireless range: At least 7 km
- Inbuilt vibration sensor to detect theft and vandalism
- Radio Frequency: 433 Mhz or 868 Mhz
- Operating temperature: -25 to +60 °C
- Digital Interface to connect to the radar level sensor and the water content sensors
- Built in rechargeable battery and a small solar panel
- The system should be operable for 3 months without a recharge.

4.4.4 Data collection platform

During a flash flood event, all equipment in the vicinity of the river might be washed away. Hence, data collection platform for sensing must be placed at a higher altitude than the maximum flood level whereas the sensors need to be at a lower altitude to sense flood. The sensors used to detect the flash flood will communicate with the DCP using low power wireless communication.

The data collection platform for GLOF sensing will consist of:

- Data Logger
- Communication Module (CDMA, GSM, Iridium and Wifi network)
- Wireless module for data acquisition from sensor network
- Digital Solar Charge Controller
- Solar Panel
- Rechargeable Battery
- Protection Housing
- Lightning Arrestor and grounding kit

Data logger

The data logger is a digital system that logs data from various sensors and records the data over time. Besides logging the data, it also transmits the data to a central server for archiving. In case the data exceeds certain thresholds, it should also have the capability to send alerts to various nodes using different communication channels. The datalogger should have following features:

- The datalogger should be remotely configurable to change any settings in the system.
- Besides logging sensor parameters, it should also log battery voltage, solar voltage, charging current, load current to monitor health of battery and communication errors to know about communication status.

- It should have internal battery-backed real-time clock that automatically synchronizes its time with global time server.
- Data Logger should have digital interfaces - SDI12, RS485, RS232 and analog interfaces.
- It should be easily programmable using a laptop/computer.
- It should withstand harsh environmental condition with operating temperature ranging from -20^{0}C to +60^{0}C.

Communication module

The communication from the DCP to the server must be very reliable and should also be cheaper. When different communication methods are available, it should choose the cheapest method such that the operational cost is minimal. The communication module should support following communication channels:

- CDMA and GSM modems
  - ***Note:** *Even though there is no CDMA and GSM at/around the vicinity of the station, the communication module will have both CDMA and GSM for data and information transmission with the assumption that eventually the place will have CDMA and GSM networks availability some time in future.*
- Satellite communication

Signal strengths, communication errors should be logged by datalogger. Any changes in the modem parameters should be achievable through web browser.

Wireless transceiver

The wireless transceiver is used to transmit the data to the gateway and relay it via the satellite communication to the central server.

Solar charge controller

- 5Amp 24 Volt digital solar charge controller
- SDI-12 Digital Interface to poll parameters like:
  - ❖ Battery voltage
  - ❖ Solar PV voltage
  - ❖ Charging current
  - ❖ Load current
- Should automatically disconnect load if battery voltage drops below 11.6V

Solar panel

- 12 Volt system
- 50 Watts
- With stainless steel support

Battery

- Type: Maintenance free VRLA battery
- Rating: 12V, 75 AH

Protection housing

- The data logger, solar charge controller, batteries should be housed in a rugged water and dust proof sealed enclosure with pad locks. It should withstand direct exposure to harsh environment.
- Protection category: IP 66 and should comply to NEMA 4.

- Should have pole mounting structures

4.5 Emergency audio notification system

The Emergency Audio Notification System is a fully automatic audio system capable of disseminating emergency notification using pre-recorded sounds and voice messages. The server is capable of uploading pre-recorded sound messages using the internet and triggering it when required. When emergency notification is to be disseminated, the first thing will be a tone that's an attention getter so people will listen, and will be followed by an actual voice that will give specific message and also instruction on what people should do. Besides the system, health status can be monitored remotely. For example, battery voltage, solar panel voltage, etc.

The technical specifications required are as under:

- For Remote terminal unit
    - Remote triggering by CDMA or GSM dual SIM for redundancy
    - Live Public Address and /or pre-recorded text messages
    - Integrated Automatic Self-Monitoring
    - Real Time Operating System
    - Common Alerting Protocol (CAP) compliant
- For horn speakers array
    - 150W
    - SPL > 116db
    - Non-corrosive metal
    - Weatherproof siren horns
    - 360^0 omni-directional sound propagation
- For Audio Amplifier
    - Class D audio amplifier for power efficiency
    - 150W X 2 channels
    - Shutdown control for power efficiency
- For Power Supply
    - 12 Volt system
    - Should use two 12V 75Ah VRLA Battery
- For solar charge controller
    - 5Amp 12 Volt digital solar charge controller
    - SDI-12 Digital Interface to poll parameters:
        - Battery voltage
        - Solar PV voltage
        - Charging current
        - Load current
- For solar panel
    - 12 Volt system
    - 60 Watts
    - With stainless steel support

4.6 Central data acquisition system and software

4.6.1 Server computer

A server computer will be required for running the data acquisition software. The server should be of enterprise class and high performance. The required technical specifications include:

- At least Intel Xenon processor E5-2600 product family
- Processor: 2
- Cache: 2.5Mb per core
- Memory: 16Gb
- Hard disk raid controller
- Hard drive bays: at least 4
- Operating system: Linux or licensed Microsoft Windows server 2012

4.6.2 Online UPS

For uninterrupted operation of the server, an online UPS is required. The specifications include:

- Power ratings: 2KVA
- Input voltage range: 170V to 280 volts AC
- Input frequency range: 47 to 53 Hz
- Output waveform: Pure sine wave
- Battery requirement: Enough battery for at least 6 hours operation without main lines
- Communication port: RS-232

4.6.3 Customized software

A customized software needs to be developed with the following modules:

- Data Acquisition Module
- Data Processing Module
- Data Presentation Module
- Remote Device Configuration Module
- Automatic and Human Assisted Decision Support System
- Emergency Alert Dissemination Module

4.6.4 Data acquisition module

This is the part of the software that receives data streams from various data collection platforms automatically. This should support encryption for security reasons.

4.6.5 Data processing module

- Quality Control
    - Data Validation based on rules
    - Rules should be simple mathematical operation and / or user defined function based on time and data
    - Invalid data should raise flags and alerts

- Data aggregation
    - Derived parameters should be produced from existing parameters such as deriving discharge using water levels and rating curves.
    - Aggregated data should raise flags and create alerts

4.6.6 Data presentation module

The data presentation module should display data points in tabular formats and graphical format; real time, hourly, daily and monthly. The module should also support GIS, showing different points on a map.

4.6.7 Remote device configuration module

The field devices such as data collection platforms, audio emergency notification system should be configurable remotely through web based interfaces via the server. It should support special administration rights for remote device configurations.

4.7 Automatic and human-assisted Decision Support System

For upstream villages, the alerts need to be disseminated without wasting any time, whereas for the downstream villages there is enough time for the data to be verified by the government officials. Hence the decision support system should support both automatic and human assisted. During alert conditions, the authorized experts are notified using SMS and emails. The experts then need to login to the system using internet and a web browser. They can then verify the data from different field devices and pictures and sound from the camera. They can then cancel the alert being disseminated to the local public if it seems like a false alarm. The system should support logging in using a web browser or an android based application for interacting with experts

4.7.1 Emergency alert dissemination module

The emergency alert dissemination module interfaces the Decision Support System to the various media that can be used for alert dissemination such as SMS, email, audio emergency notification system, etc. The technical specifications include:

- Web interface for various interested participants to register their mobile numbers and email address to receive alerts;
- GIS-based application to send alerts to specific regions;
- Android based mobile app to receive alerts using GPRS;
- SIP based module to send out live public announcement; and
- Should be Common Alerting Protocol (CAP) Compliant

4.8 Hazard monitoring and warning decision

An essential part of EWS is continuous upstream observation of hazards throughout rainy seasons. In monitoring hazards, a bottom-up approach to early warning, with the active participation of project affected/downstream communities, shall be applied which contributes to the reduction of vulnerability and to the strengthening of local capacities. Characteristics of hazard will decide which tools and equipment to be used and what warning levels should be adopted.

4.8.1 Pre-conditions for warning/alert levels

Warning levels need be based on the identified lead time and threshold. Three different warning levels shall be used as outlined in Table 13 below:

Table 13: Warning alert levels

Warning/ alert levels	**Level 1 Alert, Standby "Ready"**	**Level 2 Preparation "Get set"**	**Level 3 Evacuation "Go"**
Pre-condition	Heavy upstream rainfall (threshold value may vary as per location and	Water level in river increases by xx hours (according to	Water level in river increases by xx (according to calculated threshold) meter

	watershed) Warning Level 1	calculated threshold) meter	
Warning messages	High possibility of flash flood	Flood is inevitable within xx hours (according to calculated lead time)	Flood coming any time
TO DO LIST	Upstream observer will inform HEP which will inform the community. Upstream observer will inform HEP in accordance with the well-established communication channel.	Upstream observer will inform HEP which will inform the community. Upstream observer will inform HEP in accordance with well established communication channel.	Upstream observer will inform HEP which will inform the community. Search and rescue and first aid teams will be activated for immediate evacuation Inform nearest police station, Red Cross chapter and others for external assistance

4.9 Communication and dissemination

NWEDC shall ensure an efficient and reliable communication system with the local district administration as per the established norms for the success of disaster management plan. The communication system, as outlined hereunder, must essentially integrate an emergency alert system, a warning or control system and an emergency communication system.

4.9.1 Emergency alert system

An emergency alert is to be provided to the public immediately after sensing the disaster based on the first response (FR) received from any source. The Engineer-in-Charge must activate the Emergency Operation Centre (EOC) and accordingly the emergency alert may be disseminated. Initially, attempts will be made to control or localize the event in the first instance by looking into all technical aspects of the disaster and, if necessary, activate the needed emergency action groups to localize the event as a first response measure. If it is not possible to control the emergency, on-site emergency be declared and response action be initiated in accordance with the plan.

In addition, some facilities require operators to carry a flashlight at all times. NWEDC shall consider fire safety as a first step towards building good practice for designing and operating safer hydropower station. Whatever the nature of the crisis, people must be able to get out of the hydropower station safely. As such, the plant should have at least two independent ways to exit. If one route becomes inaccessible, an alternative emergency escape route should always be made available. Adequate lighting is essential for emergency escapes.

For life safety, fire needs to be detected as early as possible and prevent them from spreading, alert all personnel, and provide safe and well-lit means of evacuation as soon as possible. Smoke control and ventilation are also extremely important. Fire will rapidly fill a hydro station with thick and black smoke, which is often a far greater hazard to personnel than fire itself, as it obscures vision (preventing occupants from finding safe escape routes as well as hindering search and rescue operations). It can also asphyxiate or poison people well before the temperature of fire or smoke causes injury. Thus, sprinklers, venting and fire-fighting equipment needs to be put in place.

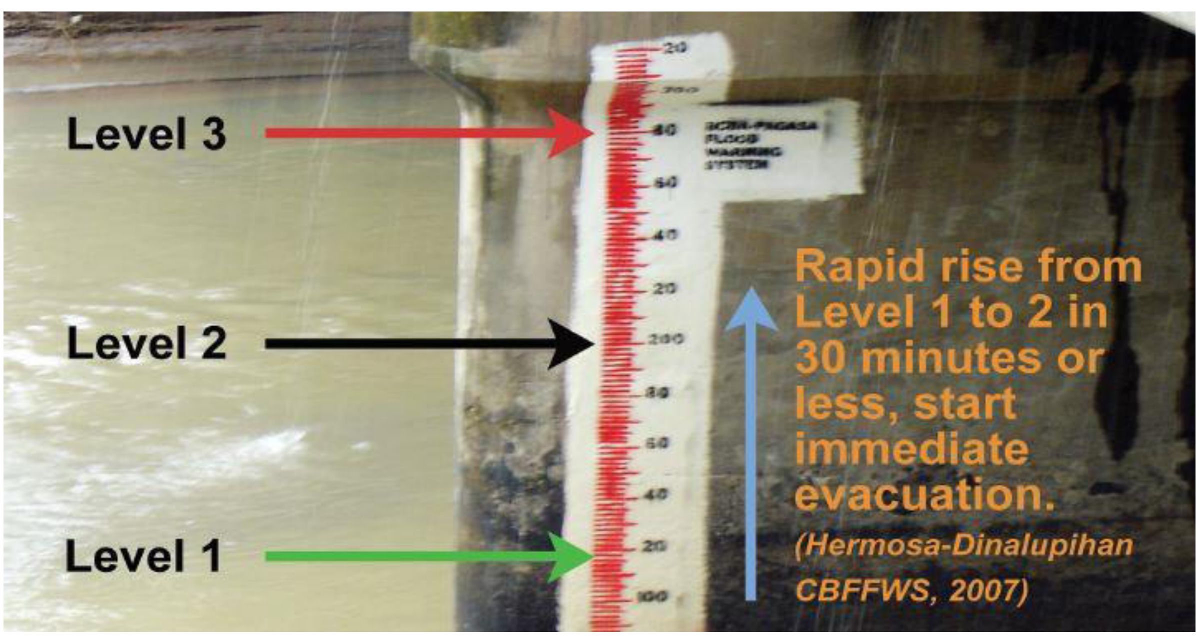
4.9.2 Emergency warning and control system

Based on the report of emergency alert, emergency needs to be notified. If the Engineer-in-Charge determines that the dam break is inevitable and affects adversely the public in downstream areas, he triggers the Emergency Operation Center and activates emergency response. Accordingly, relevant higher authorities and CDO will be informed. Thus, in the process of notification, the district administration and security authorities are alerted and public are to be alerted by appropriate warning systems such as sirens, alarms and FM radio broadcasts. Again, each type of emergency has to be given a separate code for easy identification of the type of emergency as also for notifying and seeking assistance. Suggested warning systems of sirens are as follows:

Disaster warning: High-pitched continuous wailing siren
All clear: Long continuous note

These alarms/sirens should be deployed so that all the hazard zones are covered. FM radio and walkie-talkie alert system has proved very effective communication medium during emergencies for which pre-determined codes need to be developed. In addition, danger and cautionary signs at critical points (such as in Mailung Bazar, Kalyanpur, Pahiro Besi and Betrawati) need to be installed as appropriate (as shown in Figure 15).

Figure 15: Specimen of prohibitory signals to be installed at critical flood-prone areas



4.10 Communication system

An efficient communication system and a downstream warning system are absolutely essential for the success of an emergency plan especially when time is of great essence. The difference between a high flood and a dam break situation shall be made clear to the downstream people in advance through awareness programmes. All the villages falling under the flood-prone zone or on the margins are required to be connected through wireless system backed by stand-by telephone lines. A centralized siren system is to be installed at the emergency cell of the powerhouse to communicate warning in time. NWEDC shall primarily coordinate, facilitate and interact with district administration and line agencies and follow the existing communication channel as outlined in the Rasuwa District Disaster Management Plan. The DM Plan proposes to strictly adhere to the communications channel as outlined in Chart 5 hereunder, which is linked with the District Disaster Management Committee. This is to be further developed over the plan implementation period and should include, but is not limited to:

- Designation of an emergency line in NWEDC office, to be kept clear and used only for reporting emergencies;
- Portable radios, including number, location and station for key dam operations staff;
- Means for communication during power failure and back-up provisions in the event of telephone system failure; and
- Location of phones to be used for the notification procedure

Chart 5: Proposed district level EWS communications channel

4.10.1 Emergency communication system

Besides developing alert and warning systems, emergency communication systems need to be established for effective communication within the identified hazard zone. An up-to-date telephone directory of key personnel (NWEDC, relevant district authorities, security forces, local political parties, community leaders, etc.) concerned with emergency should be prepared and made available to all concerned (Annex 4). In order to coordinate effectively, standby power arrangements and communication equipment should be given utmost importance with adequate backup data.

This step will focus on transferring information gathered during observation and monitoring of hazard to the project affected families and communities. A reliable and well-organized dissemination system should be in place for on-time information dissemination. It is, therefore, essential to develop and agree on a flow of information which needs to be well understood by all stakeholders. The system should be effective and efficient to reach all end users. The communication and dissemination system should offer alternative methods in case of failures of one or more communication channels. Information can be communicated via telephone network in the areas with good phone coverage. Wireless radios of security forces may be used in areas with no or limited phone coverage.

4.10.2 Tools and equipment

NWEDC shall arrange sufficient number of telephones, wireless sets, sirens, colored flags and mobilize local FM stations in the event of disasters. A separate telephone directory with contact details of gauge observers, stakeholders (VDC and district authorities, police and army posts, media) and communities should be maintained and distributed. The contact details include names and telephone numbers of contact persons (alternative phone numbers, if available). Telephones requiring electrical power (or charging) should be supplied with additional batteries and/or solar systems. Following are the proposed list of tools and equipment required for managing disaster for downstream affected families:

Life jacket, search light, first aid kit, stretcher, inflatable boat, reflective water proof jacket, blanket, sleeping mats, safety helmets, hand mikes, disaster management kit (tarpaulin, bucket, rope, etc.), hygiene kit, food and non-food items. In addition, NWEDC shall also make the following necessary arrangements (Table 14) in its field office as part of the response to any imminent disaster:

Table 14: Necessary arrangements proposed for disaster response

Sector	Necessary arrangements
Communication and dissemination	• Equipment and systems are in place and tested addressing the needs of everyone
Evacuation	• Evacuation routes are identified and marked • Special equipment for different types of impairments are arranged • Proper locations are identified to evacuate different community groups • Volunteers are trained to manage evacuation
First aid	• First aid teams are formed and trained • First aid kits are in place and replenished, if needed
Search and rescue	• Search and rescue teams are formed and trained • Equipment like light, ropes, boats, life jackets, tubes, etc. are arranged • Special equipment for different types of impairments are arranged
Health	• Necessary medicines and health equipment are arranged • Proper linkage and coordination with nearest health service centers are developed for referral

Sector	Necessary arrangements
Water & sanitation	• Procedures for management of drinking water are arranged
Transportation	• Different types of transportation modes (stretcher, boat, jeeps, etc.) are identified
Shelter	• Shelter and/or safe areas are identified • Procedures for management of shelter are prepared
Relief materials	• Food and non-food relief materials are stockpiled
Data collection	• Procedures for data collection & reporting are developed (number of affected HHs, injured, deaths, evacuated persons & to which location)

4.11 Formation of Disaster Management Committee (DMC)

Upper Trishuli-1 HEP is under the preliminary stage of construction. While carrying out construction activities, it is anticipated that any emergency situation may occur at construction sites of project which may cause threat to life and property. Probable emergency may be worksite injury, loose fall/collapsing of tunnel and trapping of workmen, explosion of blasting materials; flooding of intake tunnel, vehicle accident, etc. in addition to the natural or climatic factors which may also trigger the disastrous events.

In order to effectively manage and operationalize disasters, NWEDC shall constitute a nine-member Disaster Management Committee (DMC) under the chairmanship of the its CEO (Table 15). DMC will be the focal authority to conduct and implement activities and actions on disaster management and will play lead role in all stages pre, during and post disaster stages. While the project head shall act as the member secretary, chief of dam and other departmental heads will serve as members of DMC.

Table 15: Organizational chart of Disaster Management Committee (DMC)

SN	Designation	Position
1.	NWEDC Executive	Chair
2.	Chief Engineer (Dam)	Member Secretary
3.	Chief Engineer (Power House)	Member
4.	Chief Personnel Officer	Member
5.	Chief Technical Officer	Member
6.	Chief Finance Officer	Member
7.	Chief Engineer (E&M)	Member
8.	Chief Engineer (HM)	Member
9	Safety Officer	Member

4.11.1 Roles and responsibilities of DMC

The National Strategy for Disaster Risk Management (NSDRM) empowers the district administration to oversee all disaster preparedness and response measures. The responsibility for disaster management does not lie with NWEDC alone, but is shared by various government and non-government institutions, requiring support from each and every institution as well as individuals. As disaster management is a joint effort, all disaster related interventions shall be conducted jointly with the district administration led by the Chief District Officer with the support of the institutional members of the existing District Disaster Management Authority (DDMA) that is composed of the CDO, district level head of the Nepalese Army, Nepal Police, Armed Police Force, representatives of the District Health/Education/Agriculture, and the district chapter of the Nepal Red Cross Society.

DMC provides the framework that enables NWEDC to function in an effectively and timely manner. This committee is responsible for manning the management positions in NWEDC's disaster response effort. CEO's primarily role is to coordinate at the policy level and monitor progress as it supervises and supports operations and provides oversight so that actions taken during disaster response abide by the rules and procedures of the DM Plan.

Similarly, the Head of the Project Office shall be responsible to ensure that disaster management and disaster operations in the area are consistent with the DM Plan; regularly review and assess disaster management activities; coordinate with the District Disaster Management Committee and provide technical advice as required; provide annual report to DoED about the implementation status of the DM Plan; and assist in building relationships with agencies active in disaster response in the project area.

Safety officer shall notify project head about the disaster; advise personnel in the area of any potential threat and/or initiate evacuation procedures; eliminate potential ignition sources; initiate and coordinate response actions and activate Emergency Operations Centre; and ensure that information about disaster in the area is promptly given to the DDMC.

The DMC shall have the overall responsibility to facilitate and coordinate disaster (Table 16). While the government line agencies shall be responsible for delivery of services in their respective fields in all the phases of disaster management, NWEDC shall facilitate District Disaster Relief Committee (DDRC) in realizing the following priority actions:

Priority Action 1: Assess and monitor disaster risks and enhance early warning through SMS;
Priority Action 2: Better knowledge management for building a culture of safety;
Priority Action 3: Reducing the underlying risk factors; and
Priority Action 4: Enhance preparedness for effective response.

Following is the roles and responsibilities of the members of the DMC:

Table 16: Roles and responsibilities of DMC

Before disaster	During disaster	After disaster
Ensure regular updating of the Disaster Management Plan *(Project Head)*	Coordinate with the DDRC for search and rescue *(Project Head)*	Coordinate with the DDRC to return the disaster displaced persons to their respective places *(Project Head)*
Ensure the installation of an Early Warning System for all kinds of potential hazards *(Project Head)*	Facilitate in search and rescue activities *(Project Head)*	Initiate activities for reconstruction and rehabilitation *(Project Head)*
Organize simulation exercises to assess the disaster preparedness Plan *(Safety Officer)*	Support to set up shelter camps *(Safety Officer)*	Arrange for financial support such as grants and soft loans *(Project Head)*

Make arrangement of funds required after the occurrence of the disaster *(Project Head)*	Assess damages caused and plan for early recovery *(Project Head)*	Report regularly to District Administration Office about the prevailing situation *(Project Head)*
Assess hazards, risks and vulnerability within the project area *(Safety Officer)*		Coordinate with other agencies for reconstruction and rehabilitation *(Project Head)*
Organize training of engineers, masons and technicians for the incorporation of disaster resistant works *(Safety Officer)*		

Implementation and follow-up of the plan is the most important tasks. While the district administration is the ultimate responsible agency in the event of any disaster in the project area, NWEDC shall provide all logistics and technical support in implementing the above-stated priority actions. The post-disaster emergency response, early recovery and reconstruction, and rehabilitation shall be implemented primarily under the leadership of DDRC, which is well positioned to draw additional human and technical resources from other agencies—government or non-government.

In the event of any emergency, the Chief District Officer of Rasuwa district shall be immediately informed for assistance to manage the crisis/disaster effectively. Proper coordination among the committee (CEO and departmental heads/contractors) shall be made to mobilize resources available with the project to manage any such crisis. Each working site (dams site and powerhouse) of the project is maintained round the clock by employees who are equipped with latest communication facilities. At the time of any disaster, respective site officers play a prominent role at the control room to widely communicate necessary information for resource management so as to meet exigency during emergency. These activities will also be monitored by crisis management committee of the project.

It is also important to create an emergency response team at the district level, which shall include government staff (health, police, village council, etc.) and Red Cross volunteers. The team shall provide first-aid, conduct basic search and rescue, assess the damage to structure, etc. by using emergency response kit. In fact, the team shall act as a surge team, *i.e.* assemble and conduct operation when required and then disburse.

4.12 Health and medical preparedness

Health personnel including doctors, surgeons; hospitals and ambulances have a vital role to play in the event of a major hazard. They form an integral part of medical and health emergency plan. The response plan has to cater for immediate pooling of all available medical resources and provide emergency medical treatment to the victims of the incident. A coordinated utilization of all available local medical resources in the incident areas as well as the additional resources at Kathmandu shall be mobilized. In this regard, NWEDC shall prepare a list of health facilities giving exact location, telephone number and name of key person at the facility.

Chapter 5: Information, education and awareness raising

5.1 Preparing community through information, education and communications

Information, Education and Communication (IEC) is one of the most effective means for Disaster preparedness, as it addresses the issue of pre-disaster action for capacity building of the community through knowledge, innovations and practices. As majority of the project affected people are not literate, all attempts should be made to produce a wide variety of IEC materials to ensure that no community group would be left out in the process.

5.1.1 Information

Preparing the community for disaster management through information means the transfer of basic knowledge by means of facts, figures and processes to the community so as to increase their awareness. Information addresses the questions of *what, when, where, how* and how much with respect to the expected disaster. Information in the context to dam failure such as timely interpretation of probable flood situation, anticipation of warning signals, time lag between the community area, downstream vulnerabilities, action as to be taken by the community during flood- like situation, etc. will need to be made available to the community for generating awareness.

5.1.2 Education

Education goes a step beyond information and aims at instilling behavioural change of the project affected communities through coping mechanism rather than just awareness. It addresses the values of people in question and besides making them aware of the risks, it enlightens them about their issues, the actions needed to be taken and their roles, and it motivates them to act. Education conveys to the people the significance of the question 'why" with respect to the occurrence of disasters. It tells them what to do and what not to do for preventing or mitigating disaster. It prepares them on how to manage situations and provides them with the possibilities of alternatives. Many a times people are seen to have fatalistic attitude towards disasters. They treat disaster as an act of God and express total helplessness to do anything, thereby surrendering to a disaster. Education eradicates this type of attitude of a community, especially economically deprived communities that are most susceptible to disasters and need education in disaster management.

5.1.3 Communication

Communication is the process of information exchange between two or more groups/individuals. It could be applied to both education as well as emergency management communication. In terms of education and preparedness, communication is a process of knowledge transfer to the community regarding disaster risks and mitigative measures to be taken. In this process, the system is a flow of information from a singular awakened source to the mass group, *i.e.* community. Hence, NWEDC needs to adopt pragmatic measures to create public awareness through media, posters, maps, charts, distribution of pamphlets, organizing camps, street plays, group discussions, etc.

5.2 Conduct regular simulations and drills

NWEDC shall periodically plan exercises or drills on various scenarios to assess the procedures outlined in the plan. At least two drills shall be organized in a year (April 25 to commemorate Earthquake Safety Day and October 13 as celebrated by GoN to mark the International Day for

Natural Disaster Reduction). Lessons learned from the drills and those from the previous and ongoing disasters shall be incorporated into the drill/simulation as appropriate. Each department of NWEDC may organize sectoral drills/simulations at realistic and convenient schedule. It is further suggested that simulation organized on the eve of the commemoration day of past prominent disaster will leave better impact on the ground.

The following top three mock drills/simulation exercises are proposed that can be undertaken in the project area, primarily in Dhunche and Mailung areas:

- A major earthquake in the project area (area to be identified);
- A major flooding caused by monsoonal cloudburst; and
- A fire incident

5.3 Making community participate in the process

Any emergency action plan, however efficiently it is outlined, cannot succeed if the project affected communities do not own it through their proactive participation. In order to ensure proactive participation of the project affect people, community awareness along with emergency preparedness has to be implemented so that it can foster understanding and help in controlling emergency situations.

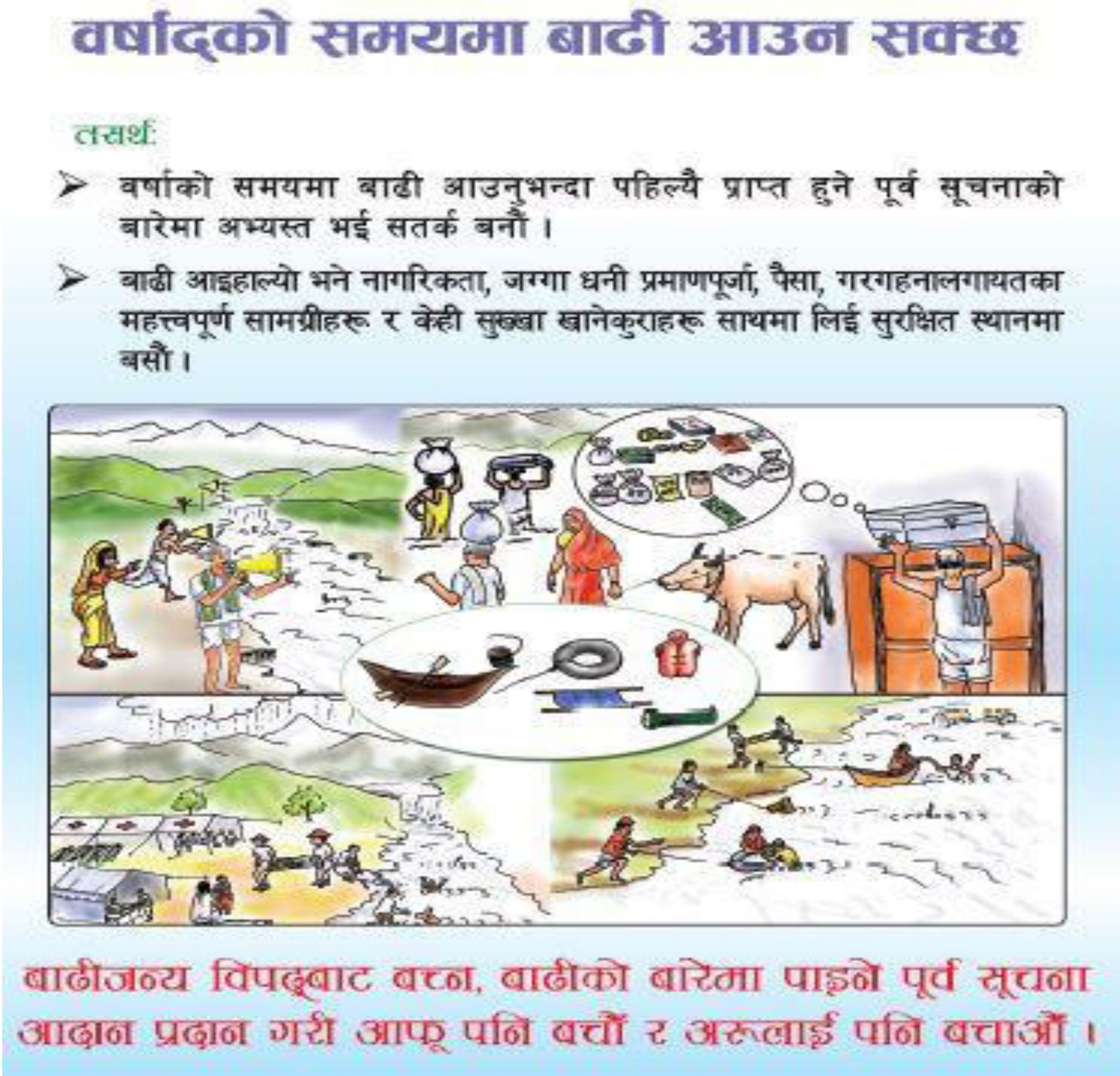
The target audience of warning system is personnel and public who are not trained about hazards, warning signals and preparedness actions. People tend to seek confirmation of the hazard from neighborhood and media, which takes time. For a public warning system, to be effective, it must serve only as a trigger to initiate pre-planned preparedness actions. Through community awareness efforts conducted for the project affected communities, people must be made aware of preparedness options, which include, amongst other, sheltering within their work place and evacuation. In addition, the project affected communities need to be made aware of the following information:

- Listen to FM radio for advance information and advice;
- Disconnect all electrical appliances and move all personal and valuable household goods beyond the reach of floodwater, if one is warned or if one suspects that flood waters may enter the house;
- Move food stock, livestock and other movable goods to the adjoining elevated place;
- Keep sources of water pollutants, *i.e*. insecticides out of the reach of water;
- Turn off electricity/gas and lock doors/windows in case one has to leave the house;
- Do not enter floodwater; and
- Never wander around a flood area.

Some basic do’s and don’ts related to disasters is very useful in reducing loss of life and property. Hence, in order to disseminate do’s and don’ts related to different disasters, NWEDC shall facilitate mass awareness activities through various means and replicate it as widely as possible within the project VDCs. Some of the medium for mass awareness shall include:

- Do’s and don’ts banner/board related to different disasters at public places;
- Use of local traditional/ethnic songs to disseminate disaster risk management theme;
- Short plays covering do’s and don’ts of different disasters shall be developed and plays shall be organized at the community level;
- Pamphlets, leaflets, etc. shall be widely distributed in Nepali language;

- Printing of maps for sharing;
- Develop a 15-minute video documentary on do’s and don’ts of disasters; and
- Mobilize skills/resources of district level partners such as Nepal Red Cross Society.



A sample information board for flood preparedness.

5.4 Public information system

During disasters, the affected people, public and media representatives would like to know about the situation from time to time and the response of NWEDC to the hazard. Hence, it is important to give timely information to the public in order to prevent panic and rumors. The emergency public information could be carried out in three phases.

Before hazard
This will include the safety procedure to be followed during an emergency through posters, talks and mass media in Nepali language. Leaflets containing do's and don'ts should be circulated to educate the affected population. Displaying of eye catching billboards at all the strategic locations can act as a warning/information.

During hazard
Dissemination of information about the nature of incident, actions taken and instructions to the public about preparedness measures to be taken, evacuation, etc. are important steps during this phase.

After hazard
Attention should be focused on information concerning restoration of essential services, movement/restrictions, etc.

Various tasks of public information system normally include:

- ✓ Quick dissemination of emergency instructions to the public;
- ✓ To receive all calls from public regarding emergency situations and respond meticulously;
- ✓ Obtain current information from the Emergency Operation Center;
- ✓ Maintain contacts with hospitals and get information about the casualties; and

5.5 Search and rescue

NWEDC shall facilitate and coordinate to address emergencies such as search and rescue in the event of any disaster. The Engineer-in-Charge shall be responsible for the entire operation, including prompt determination of the disaster from time to time. Once the red alert is declared, the whole HEP machinery will come into swing and start evacuating people based on local needs in the possible inundation areas downstream. The identified safer areas/shelters/open space that NWEDC shall prioritize for casualty management, relief and rescue operation include Mailung Bazar, Kalyanpur, Pahiro Besi and Betrawati.

With regard to communicating rescue operations, NWEDC shall ensure that any precarious situation during disasters will be communicated either by an alert situation or by an alert situation followed by a warning situation. An alert situation would indicate that although failure of flooding is not imminent, a more serious situation could occur unless conditions improve. A warning situation would indicate that flooding is imminent as a result of an impending failure of the work component/structure. It would normally include an order for evacuation of delineated inundation areas.

All senior operations staff shall review the plan and be aware of the actions required if trigger events occur. A trigger event is a circumstance or set of circumstances under which actions should be taken. Staff should be fully involved in any exercise so that their roles and responsibilities are clear should it become necessary to implement the emergency plan. Staff should be provided with feedback on their performance and re-trained as appropriate. Numbered control copies of the emergency action plan should be kept by those responsible for implementing the plan in the event of an emergency.

5.6 Mainstreaming gender-based vulnerabilities

Gender shapes the disaster experience and the ability to recover. It explains why certain groups of people are at greater risk or why some others recover at a slower pace. Since gender plays an important role in assigning roles and responsibilities within groups and in determining the access to and control of resources among groups, gender sensitivity and gender aspects need to become an integral component during disasters and throughout the rehabilitation, recovery and reconstruction process.

Women are important stakeholders in disaster management, falling among both the affected and the beneficiaries. It is important to understand the gender dimensions of disaster and the differential impacts on women so as to maximize benefits in dealing with disasters. They are typically more vulnerable than men to the effects of natural disasters, not only because of biological and physiological differences, but also, notably, because of socioeconomic differences and inequitable power relations. As a result, in most cases, mortality rates in disasters are higher – sometimes much higher – for women than for men.

The National Strategy for Disaster Risk Management (NSDRM) is a commitment of the Government of Nepal to reflect the paradigm shift towards protection as part of the fulfillment of the basic right of the people. It also expresses the desire of the people and the Government of Nepal to reduce disaster risks to an acceptable level for safeguarding their lives, properties, development investments, cultural heritage as well as to mitigate the adverse impact to the environment from natural hazards thereby contributing to the aspirations of alleviating poverty and improving people's quality of life.

After natural disasters strike, pre-existing vulnerabilities and patterns of discrimination are usually exacerbated and women face protection risks including unequal access to assistance, discrimination in aid provision, loss of documentation, and inequitable access to property restitution. Lack of security in camps, impunity for perpetrators of violence and a breakdown of social structures that is often prevalent in a crisis also result in protection risks for women. Hence, in order to prevent, mitigate and address gender protection concerns, NWEDC should strictly incorporate gender and age-based approaches that take into account the vulnerabilities and capacities of women, men and children in the entire cycle of implementing the DM Plan by providing a mutually reinforcing operational guideline as under:

- Mainstream gender and social inclusion into all stages of disaster risk management, *i.e.,* disaster preparedness, reduction, response and recovery interventions;
- Promote and provide incentives for the meaningful participation of women in disaster management, including in leadership roles;
- Ensure the implementation of rights-based approach to disaster preparedness, response and recovery activities;
- Promote voice, participation and empowerment of women, and reduce opportunities for elite capture of funds and risks to the safety of women and girls;
- Protect life, security and physical integrity of women exposed to imminent risks;
- Equitably provide food, health, shelter, and education during post-disaster period;
- Identify potential entry points and interventions to enhance gender sensitivity, mitigate adverse impacts, promote women participation, maximize benefits for women;
- Collect and maintain gender-disaggregated data on disaster;
- Pay special attention to protection against violence, including in camps and temporary shelters during and after emergencies;

- Protect against gender-based violence, trafficking, child labor and contemporary forms of slavery;
- Ensure all community members, including and especially women, have access to information and training sessions on dam safety, construction issues and road and water safety awareness;
- Ensure there is female representation at leadership level in all key community level institutions; and
- Appoint and train a gender focal point in NWEDC responsible for liaising on gender issues between project management, field staff, project monitoring unit and other external stakeholders.

5.7 Notification procedures

Notification is an integral part of the Disaster Management Plan that includes communications of either an alert situation or an alert situation followed by a warning situation. Any emergency shall be immediately intimated through communication system to the Head of the Project and other departmental heads. The project head in return shall inform the District Administration Office (CDO) about the event. The early warning stations shall sound alerts to inform the communities about the danger posed through the disaster so that they can move to safer places. For a regular watch on the flood level situation, it is necessary that two or more people man the flood cell so that an alternative person is available for notification round the clock. Typically, two levels of notifications are suggested:

- *Warning:* circumstances indicate that there may be a need for evacuation in the specified area/s. Preparatory actions are to be taken in accordance with the communications plan.
- *Emergency* (or a warning followed by an emergency): immediate evacuation is required of specified areas and emergency actions taken.

The notification of a potential emergency, or full emergency, to the downstream communities and emergency response services is essential in reducing the impact of a failure. It is vital that the procedure is followed to ensure that correct communication reaches the appropriate person/s immediately. Hence, in the event of any disaster, NWEDC shall move ahead based on local needs such as demarcation/prioritization of areas to be evacuated; notification procedures and evacuation instructions; safe routes, transport and traffic control and shelter areas.

The evacuation team shall be well equipped with rescue team, medical team, medicines, emergency vans, boats and other means of transport. The Engineer-in-Charge is responsible for the entire operation, including prompt determination of the flood situation from time to time. Once the red alert is declared, the whole field level NWEDC machinery shall come into full swing and start evacuating people in the inundation areas. For successful execution, NWEDC shall ensure the provision of simulation drill exercises bi-annually.

5.8 Warning notification

The flood-prone zone in the event of dam break of UT-1 HEP shall be marked properly at the village locations with adequate factor of safety. As flood wave takes sufficient time in reaching these villages, the inhabitants shall be informed well in time through wireless and sirens, etc. so that people may climb uphill or to some elevated areas beyond the inundation zone which has been marked previously.

A clear methodology shall be framed to communicate warnings in the shortest possible time. The Engineer-in-Charge shall inform Rasuwa District Administration Office and NWEDC higher authorities immediately of any situation at the dam and provide the required details. Upon receipt of this information, NWEDC and DAO shall contact the appropriate Area Police Office informing them about the forecast of the impending danger, its nature and expected time of occurrence.

The DAO shall also formally alert the concerned departments of other agencies. This formal information may be in any agreed form, such as via telephone/SMS or by a radio/wireless signal, written communication, etc. and is to be duly documented. NWEDC must ensure that warning or notification of an emergency reaches the at-risk population on time. This may be through any means available, but may include:

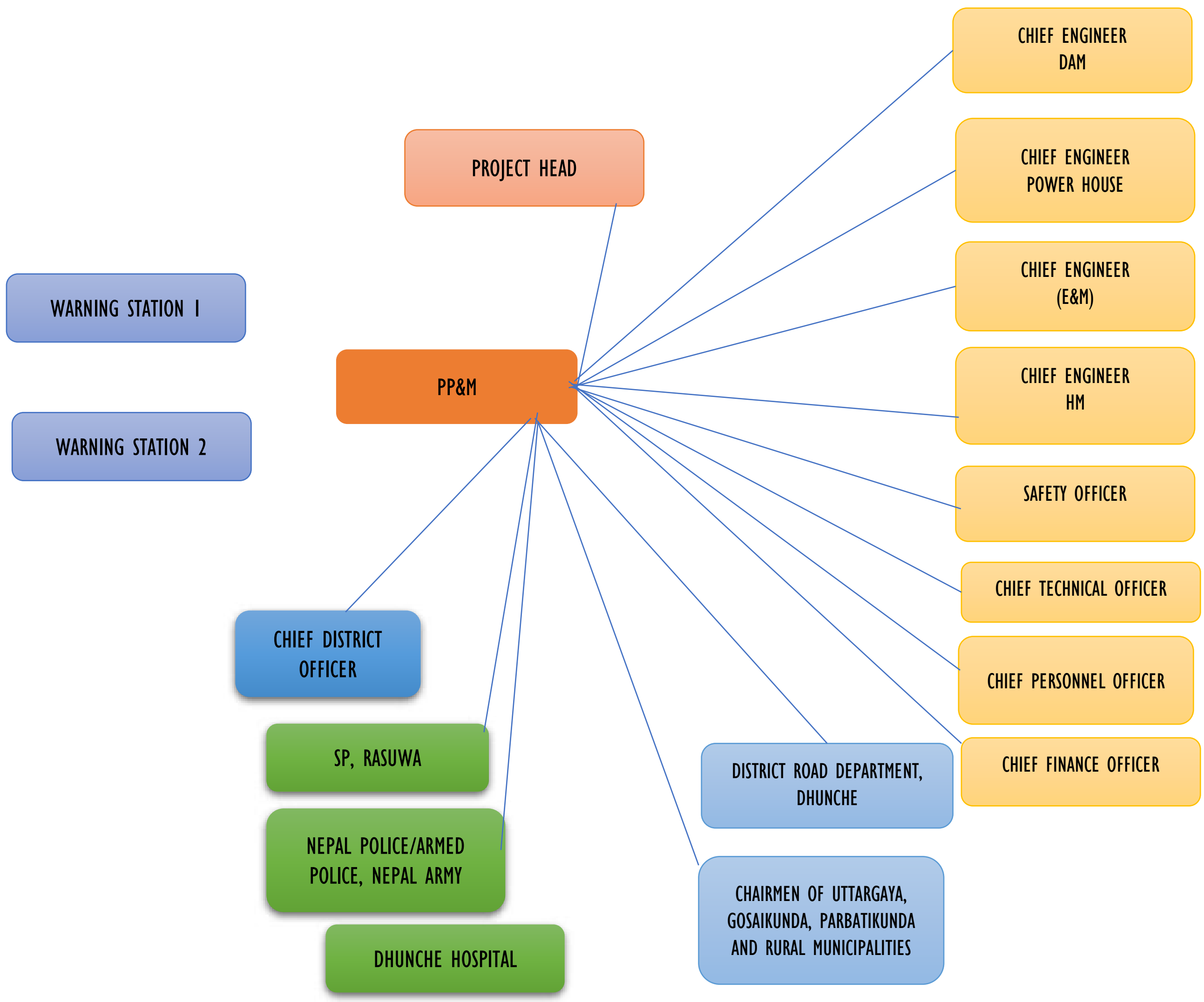
- Contacting Head of the Parbatikunda, Gosaikunda, Kalika and Uttargaya *Gaonpalikas* (if available);
- Announcements via FM radio stations, District Administration Office, police wireless system and Nepal Red Cross Society volunteers and networks;
- Sending an official to the identified areas; and
- vulnerable people.

Most vulnerable downstream communities such as such as Pokhari, Pahirobesi, Kaichaltar, Betrawati and Ramghat will have to be given highest priority to avoid any human loss. In downstream communities, announcement needs to be repeatedly made using loudspeakers and communication systems informing about the expected event and associated risks. Consideration shall also be given to the use of SMS mobile phone messaging for dissemination of announcements to Rasuwa district administration (CDO and security personnel), officials of Uttargaya, Gosaikunda, Parbatikunda and Dhunche rural municipalities of Rasuwa district), Chief Warden of Langtang National Park and chairman of the Rasuwa District Red Cross Society. It is important that the most vulnerable areas are promptly informed about any expected event. For this purpose, if required, the ward secretary or another nominated responsible person could be issued radios/wireless sets during monsoon period. These radios/wireless sets can be given in the custody of the responsible village heads. Alternatively, any other communication system in place can be used to communicate with remote areas effectively and efficiently.

5.8.1 Notification flowchart

A notification flowchart is a diagram showing the hierarchy of notification during an emergency. Following is the notification flowchart during the construction phase in case of major emergency for both upstream and downstream areas (Chart 6).

Chart 6: Proposed notification flow chart during construction phase



Chapter 6: Standard operating procedures for emergency response

6.1 General guidelines

The Disaster Management Plan will primarily facilitate project, district and central stakeholders in disaster preparedness, mitigation and response. Accordingly, NWEDC will lead the coordination mechanism and the whole operation during disasters. In the event of a disaster, NWEDC expedites response in a coordinated manner. This generally means activating the Emergency Operation Centre (EOC) to assure central coordination. Alerting, shelter, evacuation, search and rescue, and resource mobilization are all integral components of response mechanism.

As soon as the disaster strikes, NWEDC activates EOC and undertakes command and control over the entire disaster management sphere as efficient command and control is an essential pre-requisite to the successful coordination of resources in emergency response operations. This operation is based on three phases, namely, alert, activation and stand down. However, depending on the type of disaster and level, the phases and actions may overlap at times. It will be the discretion of the NWEDC to activate the appropriate action as the conditions and resources may suggest.

One of the main tasks of NWEDC is to pay special attention to stop or avoid rumors and share actual information and NWEDC will assign a dedicated staff to attend to media and incoming public calls. Accurate information sharing will avoid the generation of rumors and fake information. The impact of hazard or disaster will not be treated as confidential in general. Decision making Information on which decisions has to be made should be treated as confidential. The following guidelines will be used as Standard Operating Procedures (SOPs) for information management:

- Accurate and timely information will be shared with DoED, DAO and public;
- Daily bulletin will be prepared and disseminated accordingly in early stages;
- Focal person will be appointed to manage media, share updates regularly;
- Media “background information” sheet will be regularly updated; and
- Media visits to disaster site will be organized by NWEDC.

6.2 Compliance of IFC safeguard policies

With environmental and social responsibility becoming increasingly important, UT-1 HEP aims at implementing a management system in line with the requirements of IFC Performance Standards. NWEDC needs to articulate IFC’s strategic commitment to sustainable development by creating awareness and engagement of staff in identification and prioritization of environmental and social risks and impacts as per IFC’s sustainability framework. IFC’s sustainability framework comprises IFC’s 8 Policy and Performance Standards: (i) assessment and management of environmental and social risks and impacts; (ii) labor and working conditions; (iii) resource efficiency and pollution prevention; (iv) community health, safety, and security; (v) land acquisition and involuntary resettlement; (vi) biodiversity conservation and sustainable management of living natural resources; (vii) indigenous peoples; and (viii) cultural heritage.

Accordingly, NEWDC is required to apply these performance standards to manage environmental and social risks and impacts so that it does not trigger out any unsustainable practices during the construction phase of UT-1 HEP, and helps implement an environmental and social management system that is designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable manner.

6.3 Establishment and functioning of the Emergency Operations Centre (EOC)

The Ministry of Home Affairs (MoHA) has prepared a guidance note on disaster preparedness and response planning which calls for setting up of the District Emergency Operation Center in all the district. However, Rasuwa district has not established the center as yet and the District Disaster Relief Committee (DDRC) serves as a link to feed disaster related information to the National Emergency Operation Center (NEOC) that is housed within MoHA. NEOC is a coordination and communication point for disaster information across Nepal, including government agencies and other response and recovery stakeholders such as Nepal Red Cross Society, UN agencies, INGOs and NGOs.

As the 2011 guidance note requires all agencies to provide real time disaster data to the NEOC at the central level, the establishment of the Emergency Operation Centre (EOC) within NWEDC will contribute to the institutional strengthening and capacity building of the DDRC at the local level. Again, this mechanism will help in disaster response planning and identify general preparedness actions to address emergency action plans.

The purpose of the establishment of EOC is to share real time information and coordinate with the emergency response team. The physical size, staffing and equipping of a EOC will depend on the size of disaster, resources available and anticipated incident management workload. EOC should include the following core functions: coordination, communications, resource dispatch and tracking, information collection, analysis and dissemination.

As EOC plays a vital role during any emergency operation, it coordinates the flow of information with respect to activities associated with relief operations. The EOC works as a centre for decision-making and helps flow of information horizontally and vertically to the respective project departments for smoother rescue/relief operations. In the event of a disaster, the project's Disaster Management Unit shall activate the EOC and take operational lead for the overall response. The EOC shall act as a nodal resource centre, especially designated centralized facility where officials meet 24 hours a day to respond to the recovery efforts in support of field operations. It will be physically located within the project field office and will be looked after by the Engineer-In-Charge under the direct supervision of NWEDC's General Manager.

During normal times, the EOC will maintain a systematic database of the resources available, update important telephone numbers, names and addresses of important district and central level government officials, Nepal Red Cross Society, local bodies, political parties, CBOs, media, civil society organizations and project affected families. For the effective operation of the EOC, the following facilities need to be put in place: central operation area, workstations for liaison personnel, display boards to allow for the display of current information, effective communication, emergency power supply, conference/media room, communication gadgets (CDMA/NCell/sky phone, hotline, walkie talkie, HF radio set, hand held GPS unit and camera, etc.), inverter for power back, portable generator set, etc.

In the event of any disaster, the EOC shall perform the following functions:

- Collect information about the vulnerable and risky areas;
- Monitor emergency operations and developing secondary threats;

- Carry out assessment of damages and needs in disaster-prone areas;
- Control and manage project level emergency operations;
- Coordinate for preparation, mitigation and response with all district level stakeholders;
- Send mobile alert messages to project affected community members;
- Coordinate resources for project VDC and village level emergency functions;
- Receive and process disaster alerts and warnings from DAO, DHM and rural municipalities *(Gaonpalikas)*, and communicate to all designated authorities;
- Ensure that the district government and the communities are alert and are kept informed of evolving situation;
- Requisitioning additional resources during the disaster phase; and
- Access of information and communication to general public and media.

6.4 Reporting and documentation

The DMC shall be responsible for ensuring that all required reports are forwarded to DoED on time. It will be also responsible for preparing and sending any special reports on damages, threats or assistance needed. Locations and services offered at temporary medical or shelter facilities in particular, shall be rapidly disseminated to the district line agencies such as DAO and security agencies. An after-action report shall be prepared on the deactivation of the EOC which signals the official end of the response. This report will be used in a debrief of the operations, which is vital for learning lessons, which are meant to continuously improve disaster response.

Documentation at all levels of work done is necessity for any references and analysis of data/information in future as and when required. Role of operation staff is very important in registering all valid information operating parameters such as temperature, vibrations pressure, generation, voltage current, etc. in the operation log books and shift registers. Every event shall clearly mention frequency, voltage, MVAR, MW, MWH at the instant with other necessary data, *e.g.,* alarms, annunciations temperatures, forebay levels/reservoir levels, inflows, etc. as may be necessary from case to case. Any tripping event shall be clearly noted with relevant details such as relay operation details, disturbance recorders and event logger print outs. Restoration activities after every tripping should be reported with details of preventive action taken or to be taken based on certain conditions.

This information shall be presented in the prescribed format, checked on daily basis by the designated site manager who shall check and authenticate the same for future use. For maintenance also, similar registers are maintained giving details of maintenance activities at different frequencies such as daily, monthly, annual, etc. or breakdown maintenance. The following log books (Table 17) shall be regularly maintained.

Table 17: Operating condition record sheets

Type	Description of Log	Purpose/used for	Location/authority
1.	Log books	Very important station record of events. Helps during even analysis by others	Project site
a.	Control Room Shift Log Book	Record of events date and time wise and sequential in case of operation carried out. This will also record any instructions given or	Control Room Shift In-Charge

Type	Description of Log	Purpose/used for	Location/authority
		taken from. Left side of the page to record specific equipment operated and right side events such as tripping, set synchronizing, taking over shift with signature switchyard operations, etc.	
b.	Turbine Room Shift Log Book	All turbine and its Aux. operation and events, same as *1a* above	Turbine operator
2.	Log sheets	Gives station equipment load condition. Helps in assessing during event analysis	Project site
a.	Control Room Meter Reading	Hourly readings of all panel meter, transformer auxiliaries, generator and transformer temperature, and general condition of equipment. ambient temperature	Control room/shift engineer
b.	Control Room Energy Meter Log Sheet	Hourly KWH meter, import – export meter. Aux. consumption meter	Control room/shift engineer
c.	Turbine Room Log Sheet	Hourly readings of bearing temperature, aux. in service, pumps running, cooling water pressure, compressor air pressure, etc. turbine water head/pressure and other quantities as per manufacturer	Turbine operator
3.	Defect cum Equipment Record Books	Equipment defects noticed by operation and action taken by maintenance department	Corrections to be recorded by engineer.
a.	Defect Log Book – Electrical	Record of electrical equipment defects noticed during shift needing attention of maintenance department	Control room/ Shift charge/ assistant shift engineer. Equipment under their scope.
b.	Defect Log Book – Hydraulic	Record of equipment defects on hydraulic equipment noticed during shift needing attention of maintenance department	Turbine room/ shift charge/ assistant shift engineer. Equipment under his scope
4.	Monthly Generation Record Register	Keeps monthly total of unit generation, consumption, running and shut down hours, outages, forced and emergency outages, maximum equipment temperatures during month, water utilized, rainfall, lake contents etc., plant load factor, availability factor etc. Data is important in studying plant performance over years	Control room shift charge engineer
5.	Daily Report Book (Duplicate)	For sending daily short summary to main office of important events in plant; shall give rainfall, lake	Control room Resident engineer/

Type	Description of Log	Purpose/used for	Location/authority
		condition, water utilized, water rate, generation, outages, tripping of lines etc., and any other operation related information. DC battery related voltage. Over loading of units, etc.	manager operation/ shift charge engineer.
6.	Station Water Consumption Report Monthly (duplicate)	Keeps records of daily/monthly water discharge for generation, leakage, wind and evaporation losses for storage dams, meteorological and atmospheric data, at lake and at power house	Control room. Resident engineer/ manager operations. Head works engineer.
7.	Station Occurrence Record	Record of all tripping, time loss & cause of tripping, relay action etc.	Resident engineer/ operations manager
8.	Relay Setting Register	Record of all relay equipment relay setting giving normal condition and during outage of transformer or line, record of all instructions for revision. This is an important register shall be available for reference at all times.	Resident engineer/ operations manager
9.	Dam Operation Manual	Manual giving all operation procedure for outages etc. Giving all equipment data and equipment operating parameter. Guidelines for emergency operation, black start procedure, starting and stopping of units, lake discharge and other hydraulic data, all mechanical installation operating procedure and drawings, station interlocking drawings	Resident engineer/ operations manager
10.	Dam Safety Manual	Safety procedure for giving outages, and tagging procedure; use of tools, cranes, compressor, pumps etc. instructions giving use of fire protections and fighting equipment; first aid instructions	Resident engineer manager operation, medical officer; safety officer, if appointed separately
11.	Disaster Management Instructions	Gives details of instructions to be followed by shift staff during any disaster. It further gives details of how to act and tackle the disaster.	Resident engineer/ shift in-charge

6.5 Grievance redressal mechanism

NWEDC shall establish a grievance redressal mechanism to allow to appeal against any disagreeable decisions, practices and activities; technical and general disaster-related disputes. The community shall be made fully aware about the procedures for doing so verbally and in writing during project information campaign and consultations. At the very outset of the plan implementation, a Grievance Redress Committee (GRC) shall be formed in order to address the grievances of aggrieved community member. Prior to approaching GRC, complaints of the community member on any aspect of the project shall in first instance be settled in written form which can be discussed in an informal meeting with the community member to settle the issues at the local level. Community consultation may also facilitate the process in this regard. All the grievances shall be reviewed and the decision shall be made and informed in writing to the complaining party within two weeks of receipt of the complaint.

GRC shall be formed comprising project manager, representative of the local community (one from each of project VDCs, a representative of the village council, and a representative of a local community-based organization. The GRC shall be headed by a person of repute from the project area. Such person can be a retired government officer or principal of a school or a legal practitioner, etc. It has to be ensured that the head of the GRC is not a serving government officer. The objective of GRC is to settle all disputes through consultations and to reduce the number of cases. Social mobilizer shall help the community member in bringing out their issues related with the project before the GRC for redressal. It is expected that the social mobilizer and community member shall try to resolve the case amicably before approaching GRC.

If the community member is not satisfied with the preliminary level of redressal outcome, the social mobilizer shall forward the case to GRC for formal proceeding. The GRC would hear complaints lodged by the community member and facilitate solutions. The GRC may undertake field investigation with concerned community member, if required. The GRC will resolve the grievances of eligible persons within the stipulated time period of one month. The response time prescribed for GRC is 15 days. The GRC shall meet at least once in a month, or may meet more frequently depending upon the number of cases. The decision of the GRC will be final, unless vacated by the court of law. The decision of the GRC will not be binding for the community member to take recourse to the civil court, if she/he so desires. The GRC will continue to function for the benefit of the community during the entire cycle of the DM plan implementation. The social cell shall maintain the grievance record for each and every case. The proposed mechanism for grievance resolution is given below:

Stage 1

Complaints of the community member on any aspect of the disaster management shall in first instance be settled in written form in field based project office. Such complaint/s can be discussed in an informal meeting with the community member by the Social Development Officer of the NWEDC's social cell and representative of the project manager to settle the issues at the local level. Community consultation may also facilitate the process in this regard. All the grievances will be reviewed and the decision will be made and informed in writing to the complaining party within two weeks of receipt of the complaint.

Stage 2

If the complaining party is not satisfied with the response from the Social Development Officer, the complaining party can appeal to the GRC. While lodging the complaint, the complaining party must produce documented evidence to support her/his claim. All the grievances will be reviewed and a decision will be informed to the concerned party within a month of the receipt of complaint. Any complaining party can exercise its constitutional right to approach the court of law at any time if she/he desires so.

6.6 Administrative procedure

The administrative and procedural aspect of the DM Plan consists in a flowchart depicting the names, addresses and telephone numbers of the responsible and coordinating officials. In the event of potential emergency, the observer at the site is required to report it to the Engineer-in-Charge through a wireless system, if available, or by the fastest communication system available. The Engineer-in-Charge shall be responsible for contacting the District Administration Office based in Dhunche, Armed Police Force, Nepal Red Cross Society and village councils. A centralized siren alert system shall be installed at the powerhouse so that in the event of a warning, all adjoining villagers can be alerted through sirens rather than informing everybody through messengers which is not feasible in such emergency situations. Table 18 below provides the list of key contact details of NWEDC officials.

Table 18: Important contact details of NWEDC officials

SN	Designation	Contact No.
1.	CEO	+977-01-4412229 +977-9801027111
2.	Chief Engineer (Dam)	+977-0106923014
3.	Chief Engineer (Power House)	+977-0106201014
4.	Chief Personnel Officer	+977-0106923014
5.	Chief Technical Officer	+977-0106201014
6.	Chief Finance Officer	+977-9801038222
7.	Chief Engineer (E&M)	+977-0106923014
8.	Chief Engineer (HM)	+977-0106201014
9.	Safety Officer	+977-0106923014

Note: Important contact details of Rasuwa district administration and rural municipalities is given in Annex 4.

6.7 Disaster mitigation register and rapid damage assessment

A disaster mitigation register shall be prepared to keep record of any hazardous event faced by the project along with its intensity, action taken and discrepancies observed. In addition, a rapid assessment checklist shall be prepared to determine the precise nature and extent of damage so that timely rescue and relief measures can be undertaken in the disaster affected areas. The forms and logs for dam emergency incident is given in Annexes 6 and 7. Further, record of any future disaster and mitigation measures taken in respect of the project shall also be recorded in the register so that it can add value to improve the plan at a later stage, if required. After the mid-term evaluation of the DM Plan, few activities may warrant amendments, which may be updated in due course of time. A few suggestions for updating the DM Plan are as under:

i. Disaster is a continual process and plans for the safety of people and project, and it calls for continuous improvements with the passage of time and in accordance with the resources available at different locations.
ii. NWEDC shall continuously strive for better communication in future, which shall be helpful in the mitigation of disasters occurring in future. The information shall be updated and included in the updated disaster plan at a later stage.
iii. Health posts, *Gaonpalika* office and schools in project area can act as rehabilitation centers. The list is exhaustive and will need to be continuously improved.
iv. Various roads and bridges will be built across Trishuli River and various rivulets on the way, which will improve/help the evacuation action plan and different escape routes. This may be included as per the progress of these roads and bridges.
v. For dam safety, details of instrumentation for dam complex shall be included in the document in detail after the finalization/installation from design office/field office.

Chapter 7: Disaster Management Plan and its implementation schedule

7.1 Implementation Plan

NWEDC will be the overall implementing agency for the execution of the DM Plan both for construction and operation phase. The plan will be implemented immediately after its endorsement from DoED encompassing both construction and operational phase. NWEDC will review the progress of the plan implementation on a quarterly basis. It will prepare an annual report on DM implementation, which shall be submitted to DoED. NWEDC will also organize mock drill or table-top simulation exercises to check the effectiveness of the plan or systems and identify areas of improvement. These mock drills and simulation exercises can be organized at district, community, hospital, school, etc. levels.

7.2 Implementation schedule

NWEDC will ensure the timely implementation of the Disaster Management Plan both for construction and operation phase. The tentative timeline for the implementation of the five-year DM Plan begins from January 2018. The implementation schedule is given in Table 19 below:

Table 19: Five-year implementation schedule of Disaster Management Plan

SN	Activities	Year 1	Year 2	Year 3	Year 4	Year 5
1.	Establish Disaster Management Committee (DMC)	■				
2.	Install two Early Warning Systems (EWS) to disseminate warning messages very quickly to the people at risk	■				
3.	Develop an efficient and effective communication system which will enable to disseminate emergency messages to focal persons at a time without any time loss	■	■	■	■	■
4.	Launch awareness campaign related to early warning through IEC materials by mobilizing media (FM radio)	■	■	■	■	■
5.	Jointly celebrate Earthquake Safety Day (Apr 25) and Int'l Day for Disaster Reduction (Oct 13) with DAO	■	■	■	■	■
6.	Coordinate search & rescue operations	*As and when required*				
7.	Facilitate evacuation	*As and when required*				

8.	Conduct hazard risk analysis and produce updated hazard maps					
9.	Produce and disseminate regular information products to public using communication equipment and media					
10.	Assign roles and responsibilities of emergency focal persons and arrange necessary training					
11.	Organize community level simulations (mock drills)					
12.	Develop linkages with private sector for DRR activities					
13.	Establish Emergency Operation Centre (EOC)					
14.	Establish Grievance Redress Committee jointly with DAO					
15.	Ensure availability and operational readiness of all emergency equipment					
16.	Coordinate with local administration and security for relief and response					
17.	Provide logistics support (emergency transportation, warehousing, inventory and pre-positioning of assets and resources					
18	Provide basic training on DM to field staff					
19.	Provide ToT on DM management					
20.	Carry out regular monitoring and evaluation					
21.	Conduct mid-term evaluation					

7.3 Monitoring and evaluation of the Disaster Management Plan

Monitoring and evaluation (M&E) is an invaluable component in successfully implementing the plan. As monitoring involves periodic checking to ascertain whether activities are going according to the plan, it can provide critical information to NWEDC, in a timely manner, which guides the proper implementation of the plan. It provides the feedback necessary for NWEDC to keep the targeted activities on schedule. By contrast, evaluation is essentially a summing up, the end of the plan assessment of whether those activities actually achieved the core objectives of the plan.

In view of this, NWEDC shall carry out regular internal monitoring of the Disaster Management Plan on a monthly basis. It shall hire an independent external evaluator to conduct mid-term (after the completion of two years of implementation) and end-term evaluation (five years) of the DM Plan to verify:

- Actions and commitments described in the DM Plan are implemented fully on time;
- DMP actions are effective;
- Complaints and grievances lodged by project affected people are followed up and that where necessary, appropriate corrective actions are implemented.

The external evaluator may change DMP activities and implementation procedure (if required) to improve effectiveness of the actions. Again, the monitoring unit shall be responsible for the preparation of the Disaster Monitoring Report. The report shall be disseminated through Project Manager's Office to the concerned agencies that includes DoED and Project Management Unit, among others. In general, the unit shall prepare disaster monitoring report during the construction phase on an annual basis and shall be provided to DoED for comments. A final disaster monitoring report shall be prepared after the completion of the construction work.

Key performance indicators shall be monitored and reported annually to assess the progress of the implementation of the plan. Key indicators shall measure the expected outcomes of the plan; set benchmarks; measure the effectiveness of activities; and identify gaps and opportunities for improvement that lead to the enhancement of the plan's delivery.

7.4 Review/updating the DM Plan

The DM Plan of UT-1 HEP is a guiding document on disaster and, hence, NWEDC shall regularly update it as risk profile and capacity in the project area changes. The plan shall be updated using findings of the mock drills, analysis of any past disaster and changing district profile, and may incorporate sectoral DM related activities as stated in Annex 1. In updating the plan, NWEDC must ensure the involvement of all concerned stakeholders.

7.5 Cost estimates for the implementation of the Disaster Management Plan

The total required budget for the implementation of the Disaster Management Plan is NPR 1,13,89,100 (USD 111,800), which will be utilized from the budget earmarked in EMP for Disaster Management Plan. EIA report (page 369) has allocated USD 2,931,812 (*USD two million nine hundred thirty one thousand eight hundred twelve only)* for environmental mitigation and environmental enhancement activities. The budget for different activities required to be carried out for the implementation of the plan is given in the table hereunder:

Table 20: Estimated budget for the implementation of the Disaster Management Plan

SN	Particulars	Amount (NPR)
1.	Installation of Early Warning System in 2 sites–Mailung and Betrawati through customized EWS software application, data management centre, (i) Antenna (3x2.4 M); (ii) RF 3x2 W; (iii) Modem 3x1 No.; (iv) UPS/ solar; communication and operation	49,89,100 *(see below table for detail breakdown)*
2.	Public information system	10,00,000
3.	Surveillance and monitoring	15,00,000
4.	Purchase and install fire suppression tools and equipment such as fire pumps, alarms, hydrants, extinguishers, gears, etc.	900,000

5.	Notification, public awareness raising and DM training	20,00,000
6.	Miscellaneous	10,00,000
TOTAL BUDGET ***(One crore thirteen lakh eighty-nine thousand one hundred only)***		**1,13,89,100**

Detailed budget breakdown for networking and seamless integration of EWS

(A) Installation of Early Warning System (EWS) in two sites			
Quantity	**Description**	**Unit Price (NPR)**	**Line Total (NPR)**
2 sets	Early Warning System, Including: * Audio Remote Terminal Unit * Class D Audio Amplifer * Horn Speaker Arrays * Power Supplies * 3m mast	550,000	1,100,000
2 sets	Factory Assembly, Testing and Integration	17,500	35,000
2 sets	Transportation and Installation	105,000	210,000
Sub Total:			13,45,000
VAT (13%):			174,850
Total Cost for installing Early Warning Stations (A) in 2 sites			**15,19,850**

(B) Data Management Centers			
Quantity	**Description**	**Unit Price (NPR)**	**Line Total (NPR)**
1 set	Server for Data Management	525,000	525,000
1 set	Customized Early Warning Software Application	1,200,000	1,200,000
		Sub-total:	1,725,000
		Vat (13%)	224,250
Total cost for Data Management Centers (B)			**19,49,250**

(C) Communication, monitoring and maintenance charges for 5 Years			
Quantity	**Description**	**Unit Price (NPR)**	**Line Total (NPR)**
3 sets	Communication data charges for satellite communication * for one monitoring station	120,000	360,000
3 sets	Communication data charges for GSM and CDMA * for three monitoring stations and four EWS	120,000	360,000
1 set	Monitoring, operation and maintenance of all stations	8,00,000	8,00,000
Total cost of communication, monitoring and maintenance for 4 Years (C)			**1,520,000**
Total cost of project (A+B+C)			**49,89,100**

ANNEX 1: Sectoral DM related activities

DM programming	Related activities
Local DM components Community preparedness Early warning system Evacuation plans Contingency planning Capacity building/training for DM institutions	***Early Warning System*** Institutionalization of disaster risks Training and risk assessment methodologies Public awareness on forest fires Capacity building of stakeholders Flood mitigation micro projects Assessment and preparation of safe areas Setting up of community rapid reaction teams Damage assessment and needs analysis
Institutional linkages Advocacy Facilitation of co-ordination Institutional strengthening (linked to institutions involved in DM)	Creation of local civil society network District level information exchange among DM practitioners Building local NGO capacity in complex emergency response Integration of DP into NGO project cycles Establishment of information centres Building institutional / organizational capacity Network of DMCs
Information, Education, Communication Public awareness raising Education (linked with activities in schools) District HQ level EWS	Documentation of good practices in CBDRM Curriculum development for schools Disaster preparedness training program Regional information and exchange and cooperation among regional organizations, national networks.
Small scale infrastructure and services at community level Infrastructure support including construction/rehabilitation of bunds, water supplies, and drainage channels, disaster resistant housing, facilities, etc. Mitigation activities including resettlement	Households building houses on raised plinths Installation of raised hand-pumps with platform and drainage facilities Completion of gabion wire retaining walls Reforestation, mangrove rejuvenation natural resource management, livelihood protection and/or diversification
Stocks of emergency and relief items Strategic pre-positioning of selected items Logistics systems for rapid disbursement Warehouse systems for tracking stocks	Preparation of disaster-proof storing capacity Organization of procurement and rotation of stock Organization of regular training for stock dispatch and distribution
Livelihoods & economic assets protection Direct and indirect beneficiaries to adapt, prepare or protect their livelihoods against natural disasters (safe granaries, seed security stocks, etc.)	Agro-ecosystem and livelihood analysis Ensuring availability of inputs (seed, tools, etc.) both at family and market levels Checking livestock /grain terms of exchange Exploring and setting up rapid cash disbursement systems through banks or other mechanisms

ANNEX 2: Historical flood flow records with water discharge level & gauge height

2a: Maximum Instantaneous at Betrawati Station			
Year	**Discharge (m3/s)**	**Gauge height (m)**	**Date**
1977	935	3.34	27/07/1977
1978	924	3.32	12/8/1978
1979	935	3.34	24/07/1979
1980	941	3.35	3/8/1980
1981	895	3.27	22/08/1981
1982	851	3.19	28/08/1982
1983	740	2.98	19/08/1983
1984	955	3.41	31/07/1984
1985	2100	4.6	4/8/1985
1986	884	3.25	22/07/1986
1987	1090	3.6	11/8/1987
1988	953	3.37	1/8/1988
1989	724	2.95	8/6/1989
1990	1540	4.1	18/07/1990
1991	1160	3.68	20/08/1991
1992	1540	4.1	24/08/1992
1993	1980	4.5	10/8/1993
1994	1180	3.7	28/07/1994
1995	1820	4.36	crest
1996	2040	4.55	13/08/1996
1997	1060	3.55	12/8/1997
1998	1490	4.05	11/8/1998
1999	1440	4	26/07/1999
2000	1640	4.2	2/8/2000
2001	1430	3.98	2/8/2001
2002	1520	5.1	22/08/2002
2003	1490	5.05	18/08/2003
2004	1150	4.54	27/07/2004
2005	1380	4.9	26/07/2005
2006	1260	4.7	16/07/2006
2007	734	4	13/08/2007
2008	906	4.3	14/08/2008
2009	495	3.48	11/8/2009
2010	876	4.25	21/08/2010

2b: Mean monthly discharge at Betrawati (447) Station (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1967	47.2	37.8	35.6	62.5	63.7	137.6	430.4	518.4	326.4	119	66.8	48.2	157.8
1968	37.9	32	31	38.7	64.9	220.2	485.5	479.4	281	169.6	75.8	51	163.9
1969	40.5	35.5	33.1	38.1	62.3	133.3	398.2	451.4	335.1	128.4	67.3	47.4	147.5
1970	36.7	31.9	29.9	40.6	65.3	162.2	468.1	511.5	290.4	151.7	83.6	57.9	160.8
1971	45	38.6	36.8	46.5	65.1	348	447.9	548.9	320	153.7	81.5	54.8	182.2
1972	43	37.3	38.9	56.6	101.1	162.6	430.6	475.2	282.6	105.5	62.5	43	153.2
1973	37.3	36.8	40.2	60.4	96.8	366.2	509.8	662.5	525.1	288	99.9	65.7	232.4
1974	51.8	39.7	36.2	53.8	82.2	200	546.3	639.8	396.4	186.3	86.4	60.6	198.3
1975	51.2	46.2	44.2	60.2	91.6	263.6	548.4	560.9	515.9	222.3	110.4	69.8	215.4
1976	49.3	41.9	40.3	46.6	85.1	207.3	366.9	493.7	372.5	164.8	99.4	65.5	169.4
1977	49.1	46.9	51.2	58	86.4	203.9	560.5	574.3	361	179.4	106.7	67	195.4
1978	47	43.6	45.4	61.3	166.3	336.9	500.8	586.2	335.5	227.9	122.1	77.9	212.6
1979	53.3	42.8	43.4	54.7	104.6	198.1	442.4	451.3	266.8	143.7	87.6	56	162
1980	42	38.2	38.8	60.3	84.8	262.1	574.6	588.4	355.5	168.2	99.9	65.5	198.2
1981	48.5	42.1	43	56.1	93.3	274.1	614.6	539	339.1	148.4	95.6	62.2	196.3
1982	49	45.7	62.5	82.7	89.7	212	369.3	519.9	357.4	128.8	85.6	60.1	171.9
1983	45.8	40.3	42	44.2	77.2	164.8	345.2	448	393.9	199.9	103.6	67	164.3
1984	52.4	38.8	39.7	39.9	113.5	283.1	536.3	386.1	316.7	117.9	82.2	64.7	172.6
1985	52.5	50.7	58.4	62.2	69.5	141.3	361	320.4	336.9	200	96.1	68.7	151.5
1986	51.9	51.1	50.4	63.3	78.5	293.3	599.4	519.5	407.5	174.4	101.7	67.3	204.8
1987	50.8	45.8	44.3	58.1	82.5	235	511.7	574.6	332.7	153.7	96.3	69.7	187.9
1988	55.3	49.6	51.1	66.4	107.6	233.6	594.7	682.5	335.6	142.3	85.5	65.1	205.8
1989	57.7	48.4	49.7	62.7	142.3	245.1	451.4	541.6	369.8	157.2	79.6	56.4	188.5
1990	46.9	40.9	39.1	55.5	117.7	396.5	904.2	745.7	555.9	221.4	99.8	69.2	274.4
1991	57.2	49.6	49.6	56.6	113.4	284.7	594.9	904.5	611.3	207.7	90.3	64.8	257
1992	52.2	44.5	43.8	52	62.3	160.5	407.6	813.8	508.3	184.4	87.6	61	206.5
1993	50.5	46.6	41.8	55.7	110.4	255.7	547.4	836.7	522.4	220.5	89.2	61.5	236.5
1994	47	40.3	42.1	41.4	79.6	324	557.4	657.3	447.9	147	72.3	56.2	209.4
1995	46.9	42.9	45	57.7	194.8	422.2	622.2	756.2	413.2	177.7	108.2	60.6	245.6
1996	53	46.9	53.1	61.1	121.4	293.9	625.7	824.7	498.3	189.3	90.1	61.7	243.3
1997	49.6	45.2	43.8	49	68.4	213.2	572.7	565.5	374.3	112.6	66.3	56.5	184.7
1998	44.7	40.2	41.8	57.4	149.7	350.5	754.9	871.6	421.5	175.9	72.9	53.5	252.9
1999	43.9	38	36.6	51.7	86	242.2	790.1	779.5	593.5	268.7	92.9	61.7	257.1
2000	48.9	42	38.7	48.8	106.3	399.5	706.7	869	634.8	169.3	79.1	54.7	266.5
2001	43.1	39	34.6	36.9	72.8	366.4	668.7	756.2	443.4	148.3	70.2	50.6	227.5
2002	65.2	56.3	43.3	88.6	193.4	332.6	648.9	846.2	495.6	211.1	88.1	61.6	260.9
2003	47.6	41.3	41.3	57.8	84.4	314.3	721.9	868.8	721.6	233.5	103.1	64.3	275
2004	49.3	39	43.1	51.4	113	331.8	697.5	874.7	566.1	289.8	97.1	63.5	268

2005	52.4	54.1	53.6	63.5	104.6	251	724.7	867.6	470.6	247.7	86.4	49.1	252.1
2006	45.3	41.7	36.2	41.2	125	335.6	666	463.3	322.7	157	78.6	52.9	197.1
2007	43.9	41.8	42.1	58.3	92.9	190	422	496	382	190	104	67.5	177.5
2008	54.2	46.4	44.5	53.8	76.6	276	451	536	292	152	92.7	69.2	178.7
2009	54.2	48.6	45.5	57.5	75.1	132	314	383	277	169	86.3	64.2	142.2
2010	52	46.6	47.4	58.6	71.8	144	394	568	479	163	86.9	63.3	181.2
Mean	48.7	43	43	55.2	97.6	256.8	542.9	621.8	413.3	178.8	89.1	60.9	204.3

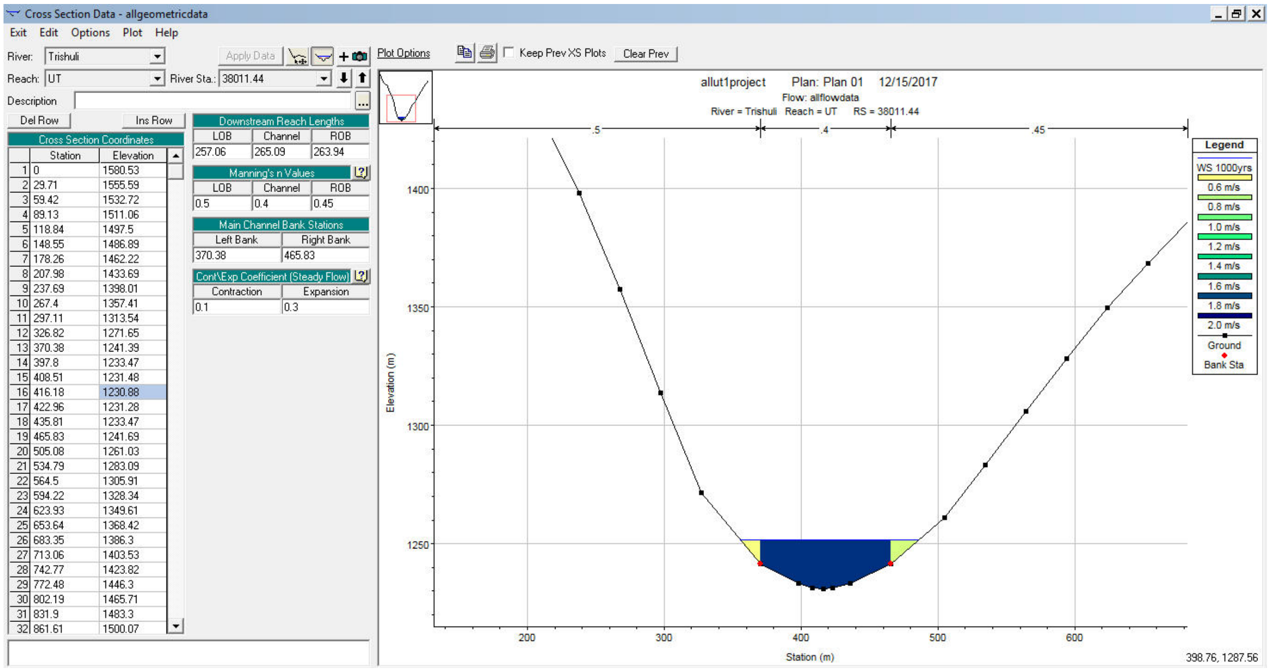
2c: Mean monthly discharge at UT-1 HEP intake area (m^3/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1967	42.3	33.9	31.9	56.1	57.1	123.5	386.1	465	292.8	106.8	60	43.2	141.6
1968	34	28.7	27.8	34.7	58.2	197.5	435.6	430.1	252.1	152.1	68	45.8	147
1969	36.3	31.8	29.7	34.1	55.9	119.6	357.2	404.9	300.6	115.2	60.4	42.6	132.4
1970	32.9	28.6	26.8	36.4	58.6	145.5	420	458.8	260.5	136.1	75	51.9	144.3
1971	40.4	34.7	33.1	41.7	58.4	312.2	401.8	492.4	287	137.9	73.1	49.2	163.5
1972	38.6	33.5	34.9	50.8	90.7	145.9	386.3	426.3	253.5	94.7	56.1	38.6	137.5
1973	33.5	33	36	54.2	86.8	328.5	457.3	594.3	471.1	258.3	89.6	58.9	208.5
1974	46.4	35.6	32.5	48.3	73.7	179.4	490	574	355.6	167.1	77.5	54.3	177.9
1975	45.9	41.5	39.7	54	82.1	236.5	491.9	503.2	462.8	199.4	99.1	62.6	193.2
1976	44.2	37.6	36.1	41.8	76.4	186	329.1	442.9	334.1	147.8	89.2	58.7	152
1977	44	42.1	45.9	52.1	77.5	182.9	502.9	515.2	323.9	160.9	95.7	60.1	175.3
1978	42.1	39.1	40.7	55	149.1	302.2	449.3	525.8	301	204.4	109.5	69.9	190.7
1979	47.8	38.4	38.9	49	93.8	177.7	396.9	404.9	239.3	128.9	78.6	50.2	145.4
1980	37.6	34.3	34.8	54.1	76.1	235.1	515.4	527.8	318.9	150.9	89.7	58.7	177.8
1981	43.5	37.8	38.5	50.3	83.7	245.9	551.4	483.5	304.2	133.1	85.8	55.8	176.1
1982	43.9	41	56.1	74.1	80.4	190.2	331.3	466.4	320.6	115.5	76.8	53.9	154.2
1983	41.1	36.2	37.7	39.7	69.2	147.8	309.7	401.9	353.4	179.4	92.9	60.1	147.4
1984	47	34.8	35.6	35.8	101.8	253.9	481.1	346.4	284.1	105.7	73.7	58	154.8
1985	47.1	45.5	52.4	55.8	62.3	126.8	323.8	287.4	302.2	179.4	86.2	61.6	135.9
1986	46.5	45.8	45.2	56.8	70.5	263.1	537.7	466	365.6	156.4	91.2	60.3	183.8
1987	45.6	41.1	39.8	52.1	74	210.8	459	515.5	298.4	137.9	86.4	62.6	168.6
1988	49.6	44.5	45.9	59.6	96.6	209.6	533.5	612.2	301.1	127.7	76.7	58.4	184.6
1989	51.8	43.4	44.6	56.2	127.6	219.8	404.9	485.8	331.7	141	71.4	50.6	169.1
1990	42.1	36.7	35.1	49.8	105.5	355.7	811.1	668.9	498.7	198.6	89.6	62	246.1
1991	51.3	44.5	44.5	50.7	101.7	255.4	533.7	811.4	548.4	186.3	81	58.1	230.6
1992	46.9	39.9	39.3	46.6	55.9	144	365.7	730.1	456	165.4	78.6	54.7	185.2
1993	45.3	41.8	37.5	50	99.1	229.4	491.1	750.6	468.7	197.8	80	55.1	212.2
1994	42.2	36.2	37.8	37.1	71.4	290.7	500	589.6	401.8	131.9	64.9	50.4	187.8
1995	42.1	38.5	40.4	51.8	174.8	378.7	558.1	678.4	370.7	159.5	97	54.3	220.4
1996	47.5	42	47.7	54.8	108.9	263.7	561.3	739.8	447	169.8	80.9	55.3	218.2
1997	44.5	40.5	39.3	43.9	61.3	191.2	513.8	507.3	335.8	101	59.5	50.7	165.7
1998	40.1	36.1	37.5	51.5	134.3	314.4	677.2	781.9	378.1	157.8	65.4	48	226.9
1999	39.4	34.1	32.9	46.4	77.1	217.2	708.8	699.2	532.5	241.1	83.3	55.4	230.6
2000	43.9	37.7	34.8	43.8	95.4	358.4	634	779.5	569.4	151.9	70.9	49.1	239.1
2001	38.6	35	31.1	33.1	65.3	328.6	599.9	678.4	397.8	133.1	63	45.4	204.1
2002	58.5	50.5	38.9	79.5	173.5	298.4	582.2	759.1	444.6	189.3	79	55.3	234.1
2003	42.7	37	37.1	51.8	75.7	282	647.6	779.4	647.4	209.5	92.5	57.7	246.7
2004	44.2	34.9	38.6	46.1	101.4	297.7	625.8	784.7	507.9	260	87.1	57	240.4

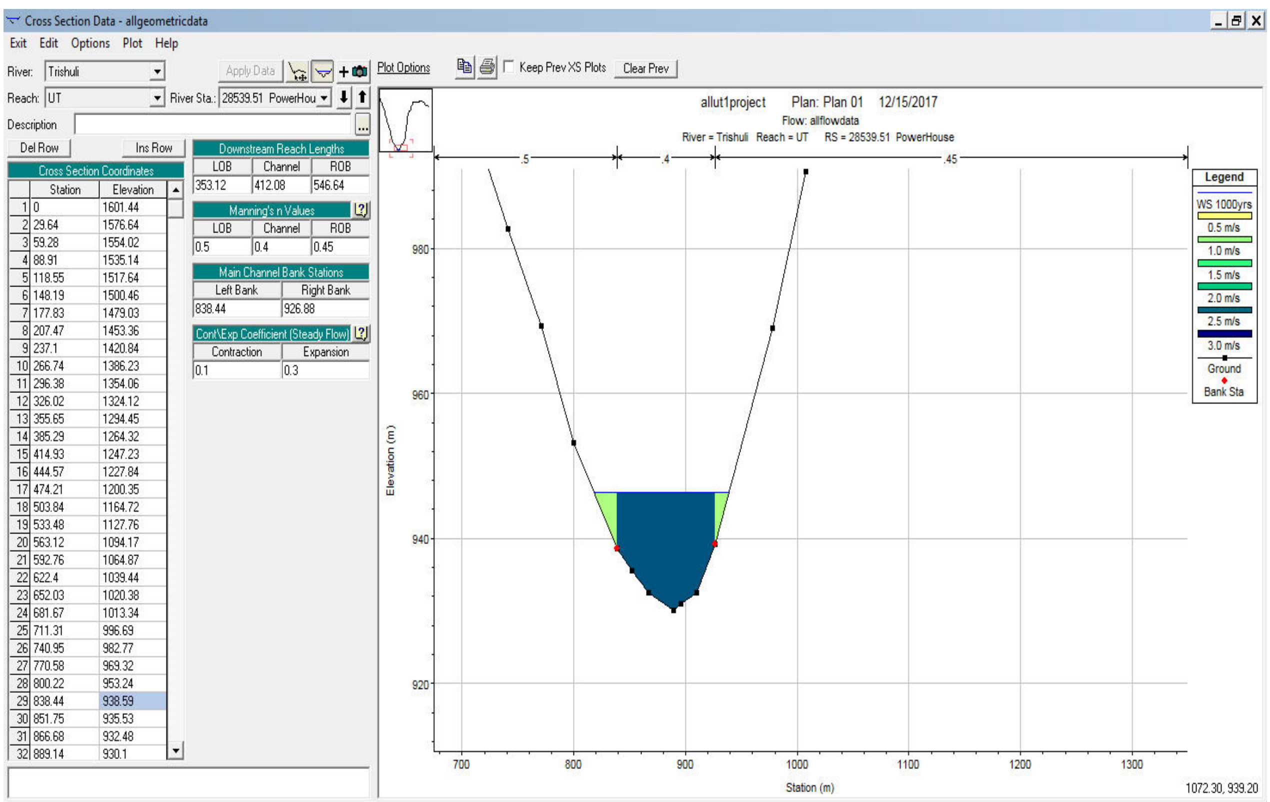
2005	47	48.6	48.1	57	93.9	225.2	650.2	778.4	422.2	222.2	77.5	44.1	226.2
2006	40.7	37.4	32.4	37	112.2	301	597.5	415.6	289.5	140.9	70.5	47.4	176.8
2007	39.4	37.5	37.7	52.3	83.3	170.8	378.3	444.9	342.4	170.1	93.7	60.6	159.3
2008	48.6	41.6	39.9	48.2	68.7	247.9	404.4	481	261.8	136.6	83.2	62	160.3
2009	48.6	43.6	40.8	51.6	67.4	118.4	281.8	343.7	248.7	151.2	77.4	57.6	127.6
2010	46.7	41.8	42.5	52.6	64.4	129.1	353.9	509.9	429.7	146.2	78	56.8	162.6
Mean	43.7	38.6	38.6	49.5	87.5	230.4	487	557.8	370.8	160.4	79.9	54.6	183.2

ANNEX 3: Cross section profiles of various locations

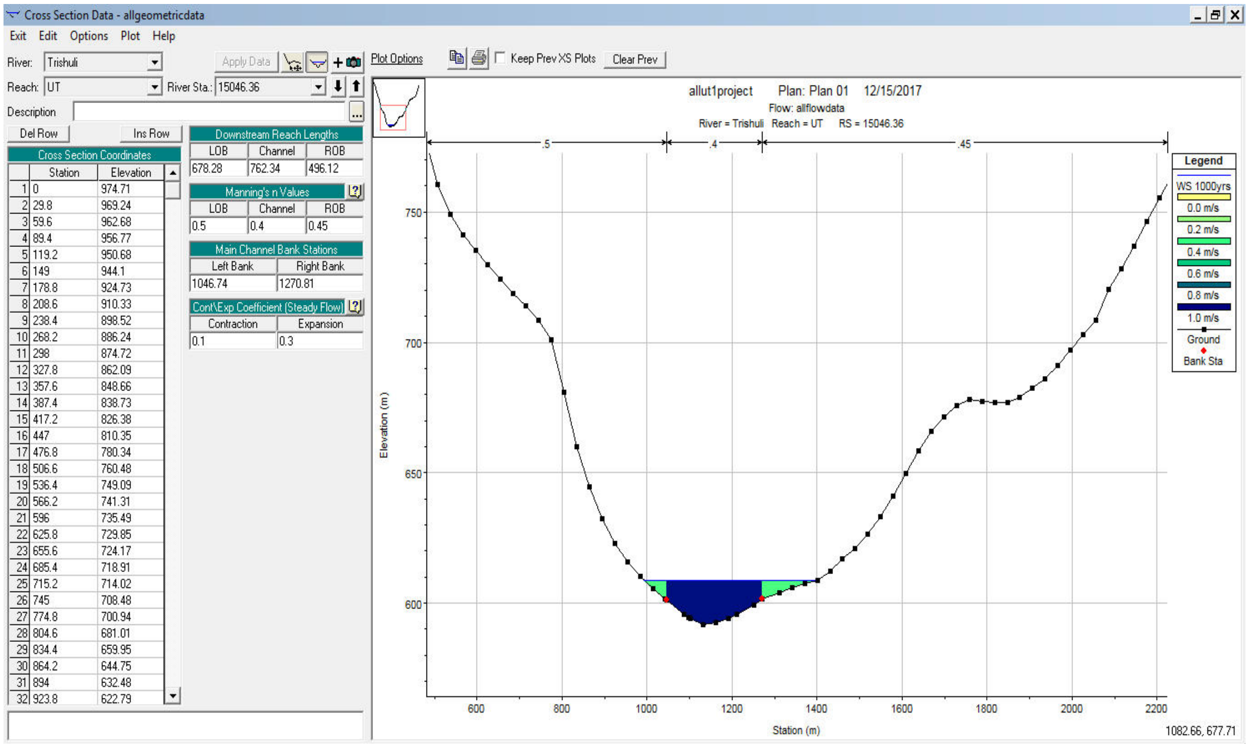
3a: Cross-section profile at Hakubesi



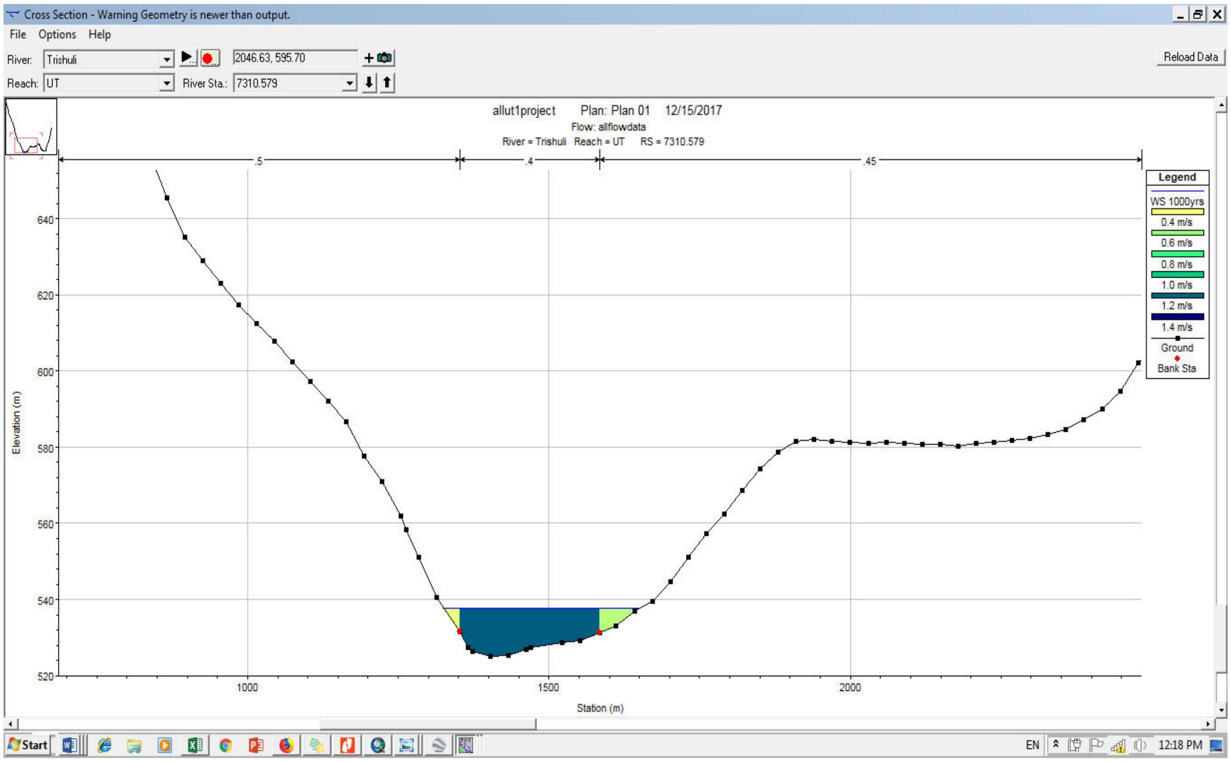
3b: Cross-section profile at powerhouse



3c: Cross-section profile at Betrawati



3d: Cross-section profile at Trishuli



ANNEX 4: Key Contacts of Rasuwa District Administration

SN	Name	Position	Contact Number
1.	Chomendra Neupane	Chief District Officer	9851277777 010-540133
2.	Smita Poudel	Assistant Chief District Officer	010-540131
3.	Rajendra Dev Pandey	Local Development Officer	010540142 9854030723
4.	Resham Lal Kandel	Planning Officer, District Coordination Committee, Dhunche	9841556671
5.	Chaitanya Prasad Niraula	District Education Officer	9741130373
6.	Krishna Raj Tiwari	District Public Health Officer	010540188
7.	Yubraj Regmi	Chief Warden, Langtang National Park	010540219
8.	Harish Chandra Sapkota	District Forest Officer	010540107
9.	Ram Awatar Mahato	District Livestock Services Office	010540129
10.	Dr. Bibek Kumar Lal	District Health Office	010540188 9851172572
11.	Sohan Mahaseth	Divisional Engineer	9852024912
	Anju Dhungana	Women Development Officer	010540263
12.	Mingmar Tamang	District Soil Conservation Officer	010540115 9844247091
13.	Rabi Mohan Koirala	Drinking Water Division Office	010540179 9846035809
14.	Tilak Bahadur Khatri	District Water-induced Disaster Division Office	010560909 9741000173
15.	Madan Mohan Shrestha	District Technical Office, Dhunche	9841379501
16.	Chemali Gurung	Uttargaya *Gaonpalika*	9851229933
17.	Bhawani Prasad Neupane	Kalika *Gaonpalika*	98416322793
18.	Buchung Tamang	Parbatikunda *Gaonpalika*	9849045336
19.	Kaisang Nurpu Tamang	Gosaikunda *Gaonpalika*	9841700755
20.	Sobit Bahadur Chhetri	Nepal Electricity Authority	010540176 9857631583
21.	Toyanath Rijal	Nepal Telecom	010540111 9751097777
22.	Babulal Tamang	Nepal Red Cross Society	9741187040
23.	Hemnath Khatiwada	President, Federation of Nepalese Journalists	9741035103
24.	Bikram Gurung	Kalijung Gan, Nepal Army	010540101 9741350177
25.	Avadesh Bista	Deputy Superintendent of Police, Nepal Police	010540199 9851275555
26.	Kaisang Nurpu Tamang	President, FNCCI, Rasuwa	9851111829
27.	Darshan Giri	Armed Police Office	010540037
28.	Bishnu Acharya	NGO Federation, Rasuwa	9741186585
29.	Saroj Adhikari	Langtang Area Conservation Concern Society (LACCOS)	010540210
30.	Temba Gyaltzen Tamang	Local Peace Committee	9741086380

ANNEX 5: Proposed check list for disaster management

Actions at normal time	Actions prior to commencement of disaster season	Actions on receipt of warning	Actions on occurrence of disaster	Actions on post-disaster activities
Bi-annual checks is conducted to revisit the DM plan & updated as required Once a month checks that all equipment is functional and maintenance is carried out as per the maintenance manual of each equipment. Monthly review meeting of all line departments in respect of all preparedness & mitigation activities Fresh training for all newly posted or refresher training of all old officials involved are carried out once every year Training of officials in the 24-hour cycle for the entire disaster season is to be completed in time Community/volunteers coordination meetings are held every month and activities fully coordinated based on experience & expertise.	DM preparedness work plan to be prepared with up to date database Fully equipped & operational equipment is checked for functionality All batteries are fully charged & generators put to trial run at least for continuous 2—4 hours Report to the extent that all actions are complete & all fully operational equipment is given to the Project-In-Charge All project staff members are fully trained & made aware of their roles & responsibilities All persons to man the DM rescue plan are fully trained & aware of responsibilities Duty roster for the plan prepared & all informed	*(All are warned, movement of vulnerable community like fishermen are restricted If special warnings issued)* DM plan is activated and made functional on 24-hour cycle Message IN & OUT registers are maintained & the control room is kept informed on minute-to-minute basis All vulnerable personnel are asked to shift to safe shelter All task forces are put into operation Warnings with clear directions for vulnerable community are passed through the fastest means of communication & checked back for accuracy Meeting of CDO, NRCS and line depts is held & clear directions for each	Nominated Officer-In-Charge start operations to supervise rescue and evacuation, relief & restoration operations Coordinate all activities of disaster site Opening of site control room with district administration Those requiring immediate medical treatment are moved to Dhunche hospital as per priority Immediate assessment made to identify damages, casualties, etc. & send the demand to the control room Men, material & resources are moved as per the requirements and priority Temporary shelters, kitchens, water points are organized & operationalized	*(Depending on the situation but preferably after three days)* Compilation of HEP damage report and report from district authorities Assistance in terms of food material, medicines, etc. provided to the affected population All stores & materials are moved as per the detailed assessment & distributed under the supervision of government officers, volunteers & responsible representatives from the community Ensure that all drinking water sources are disinfected & activated by concerned department Carry out disinfections of the disaster site Disease surveillance to check occurrence of

Information of vulnerable areas, schools/shelters, helipad & dropping zones should be made available. Awareness campaign strategy before disaster season in terms of warning dissemination procedures, individual/household safety tips, etc. planned. Coordination meeting of stock is held every quarter & emergency level of stocks to be maintained for food stuff, water, medicine, blood, kerosene, diesel, petrol, daily use household goods etc. are updated in data base. Database of transport requirement & minimum vehicles to be provided by each transporter is updated. Media management & awareness campaign strategy meeting to be reviewed every six months for coordination & implemented before every disaster season & actual disaster periods.	All storage godowns & safe shelters of all the vulnerability pockets are cleaned, maintained, fully stocked Preparedness alerts given to project affected communities Meetings of the concerned officials are conducted & all functionaries of different departments are to be fully apprised of their roles All equipment like boats, dozers, earthmovers, road clearance equipment, etc. are operational & placed at most vulnerable points Preparedness activities of all line departments like strengthening of embankments, sinking/repair of tube wells, etc. Identification of risk and vulnerable structures, buildings, land slide prone areas, possible threat areas are to be done Deployment of volunteers, doctors, nurses, beds, food materials with drinking water to be arranged	ones' responsibilities are spelt out Warning issued to disaster managers to check their men, material & equipment as per the checklist Strengthening of all individual & community houses completed All the communication equipment is thoroughly checked & all back-up battery fully charged & positioned Stockists are warned to keep assured level of stocks to move at short notice All transporters warned to keep the assured vehicles to be hired at short notice All rescue and evacuation equipment are moved to most vulnerable pockets located in far-flung areas All preparations for move to safe shelters by vulnerable community completed All CBOs/volunteers are briefed about their area of operation & ready to move	Sanitary checks & disease surveillance is put into operation Mass casualty management team is activated (if required) Regular review meeting with line departments, NGOs/CBOs held Continuous flow of information & national authorities kept informed of latest details	epidemic (if any) & preventive measures Trauma counselling (if required) is carried out for affected population A team of government officials/NGOs/ local senior citizens consisting of specialists from all fields is immediately asked to prepare a detailed report starting from the activities from pre-disaster season to the disaster & post disaster period A detailed rapid assessment report completed & submitted to DOED within one week

	Mock drills conducted & report furnished to higher authorities. CBOs made aware of their areas of operation & level of participation Coordinate meeting of all the stockiest held & each one given the level of emergency stocks that they have to maintenance during disaster season Awareness campaign launched as per the plan	Media/public briefing systems activated on hourly basis Progress is constantly monitored		

ANNEX 6: Incident or emergency event log book (Construction Stage)

Head of Department: Safety

DETECTION

When did you detect/get notified of the event?
How did you detect/get notified of the event?

ACTIONS AND EVENT PROGRESSION

Date	Time	**Action/event progression**	Taken by

ANNEX 7: Incident or emergency event log book (O&M Stage)

Head of Department: Powerhouse

DETECTION

When did you detect/get notified of the event?
How did you detect/get notified of the event?

ACTIONS AND EVENT PROGRESSION

Date	Time	**Action/event progression**	Taken by

ANNEX 8: Survey questionnaire

I am conducting a survey to prepare the Disaster Management Plan for Upper Trishuli-1 hydropower project. In order to assess how the project can build resilience of families and communities by reducing their vulnerability and increasing their ability to withstand and minimize the effects of disasters and complex emergencies by enhancing preparedness, we solicit your supoprt so that the project can ensure timely recovery from disasters and complex emergencies, and prepare communities and families in a better position to withstand future hazards.

Your feedback will help us improve the ways the project is planning to provide fast, coordinated, effective and appropriate response to future disasters and complex emergencies.

1. Flood events in the past and losses

1.1 Do you or your family have experienced Glacial Lake Outburst Floods (GLOF) and flash flood?

☐ Yes ☐ No ☐ Do not know

1.2 Information about Glacial Lake Outburst Floods (GLOF) and flash flood in the past a) Major events

SN	Year	Description of the event (flood level, timing, causes)
1.		
2.		
3.		

1.3 Which is the best location for installing early warning system in your VDC?

....

Perceptions and Information about climate change, environmental degradation and other relevant factors that affect your life and livelihoods

1.4 In the following table, please identify the natural disasters that affect your household

Code	Climate change and environmental hazards	Impact on HH? (1) YES, (2) NO	If yes, how has the impact changed in the past 10-15 years? (1) Increase (2) Decrease (3) Same
1.	Temperature rise		
2.	Excessive rainfall		
3.	Lack of rainfall		
4.	Shifting of rainfall		
5.	Riverine flood		
6.	Flash flood		
7.	Landslide		
8.	Thunderstorm		
9.	Cold wave		
10.	Drought		

11.	River bank erosion		
12.	Water logging		
13.	Earthquake		
14.	Water pollution		
15.	Ground water declining		
16.	Others (please specify)		

Impact of natural disaster

1.5 Among the following sectors, please identify how your household has been affected by the afore-mentioned factors?

	Sector	Impact on HH? (1) YES, (2) NO	Specific factor to affect household *(use code from Q.3.5)*
A	Agriculture		
B	Water		
C	Fisheries		
D	Livestock		
E	Forestry		
F	Infrastructure		
G	Health		
H	Education		

1.6 Which of the following seasons is the most crucial for livelihoods in this village?

☐ Pre-monsoon (March-Apr-May) ☐ Monsoon (June-July-Aug)
☐ Post monsoon (Sep-Oct-Nov) ☐ Winter (Dec-Jan-Feb) |

1.7 Do you think men and women are differently affected by natural disasters in this village?

☐ Yes ☐ No ☐ Do not know

1.8 Do you think that the migration of male members has implications on female members left behind?

☐ Yes ☐ No ☐ Do not know

1.9 Do you think that the migration of female members has implications on male members left behind?

☐ Yes ☐ No ☐ Do not know

1.10 In your opinion, is there any project/programme being implemented to address disaster management in this village?

☐ Yes ☐ No ☐ Do not know

2. Hazard calendar

Disasters	Baisakh	Jestha	Asar	Srawan	Bhadra	Asoj	Kartik	Mangsir	Poush	Magh	Falgun	Chaitra
Flood												
Landslide												
Fire												
Storm												
Epidemic												
Earthquake												
GLOF												
Cold wave												
Wildlife attack												
Total												

2.1 Perception of how communities will improve capacities on resilience to disasters (how resilient are the interviewees)?

2.2 Does your VDC have the Village Disaster Management Plan?

☐ Yes ☐ No ☐ Do not know

2.3 Have you ever participated in disaster management training? If so, are you aware of security planning, rescue tools, support mechanisms and risk assessment/vulnerability mapping, etc.?

☐ Yes ☐ No ☐ Do not know

2.4 Has such training increased your knowledge and skills on community-based disaster management?

☐ Yes ☐ No ☐ Do not know

2.5 Have you ever participated in emergency simulation exercises?

☐ Yes ☐ No ☐ Do not know

2.6 Have you every participated in any knowledge sharing and learning visits anywhere?

☐ Yes ☐ No ☐ Do not know

2.7 Whish disaster is of major concern to you?

☐ Glacial Lake Outburst Flood ☐ Flash flood
☐ Landslide ☐ Earthquake
☐ Others (specify)

2.8 If you needed to evacuate your house to go to a shelter during disaster, which is the safest place for relocation?

ANNEX 9: References

1. B. Shrestha, M. Eriksson, P. Mool, P. Ghimire , B. Mishra & N. R. Khanal (2010) Glacial lake outburst flood risk assessment of Sun Koshi basin, Nepal, Geomatics, Natural Hazards and Risk; http://dx.doi.org/10.1080/19475701003668968
2. D.I. Benn, T. Bolch, K. Hands, J. Gulley, A. Luckman, L.I. Nicholson, D. Quincey, S. Thompson, R. Toumi, S. Wiseman; Response of debris-covered glaciers in the Mount Everest region to recent warming, and implications for outburst flood hazards, 2011. The University Centre in Svalbard, P.O. Box 156, N-9170 Longyearbyen, Norway
3. Disaster Management in Nepal: A Profile 1994. Ministry of Home Affairs, Government of Nepal, Kathmandu, Nepal
4. Establishing Community Based Early Warning System: A Practitioners' Handbook, 2010. Mercy Corps and Practical Action, Kathmandu, Nepal
5. Estimation of Glacier Lake Outburst Flood and its Impact on a Hydro Project in Nepal, 1993. *Snow and Glacier Hydrology* (Proceedings of the Kathmandu Symposium, November 1992). IAHS Publ. no. 218,1993
6. National Strategy for Disaster Risk Management, 2009. Ministry of Home Affairs (MoHA), Government of Nepal
7. National Early Warning Strategic Action Plan, 2013. Ministry of Home Affairs (MoHA), Government of Nepal
8. Nepal Disaster Report, 2013. Ministry of Home Affairs (MoHA), Government of Nepal and Disaster Preparedness Network -Nepal (DP-Net)
9. Identification, design and development of automatic Imja GLOF Early Warning System with the cost-effective data transfer from equipment at Imja Lake to local communities and DHM web portal, 2014. Department of Hydrology and Meteorology, Ministry of Population and Environment, Kathmandu, Nepal
10. ICIMOD (2011) *Glacial lakes and glacial lake outburst floods in Nepal*. Kathmandu: ICIMOD
11. Local Disaster Risk Management Planning (LDRMP) Guideline, 2068 BS. Ministry of Federal Affairs and Local Development, Singha Durbar, Kathmandu, Nepal
12. Nepal Disaster Report, 2015. Ministry of Home Affairs (MoHA), Government of Nepal and Disaster Preparedness Network -Nepal (DP-Net)
13. National Population and Housing Census Report, 2011. Central Bureau of Statistics, National Planning Commission, Government of Nepal
14. Post Disaster Need Assessment, 2015. National Planning Commission, Government of Nepal
15. Poudyal Chhetri, M. B. 1998, "Disaster Management Policies, Problems and Measures: The case of Nepal", A Paper Presented in an International Seminar on Water Induced Disaster held from 4 to 6 November 1998 in Lalitpur, Nepal.
16. Shrestha, AB; Chapagain, PS; Thapa, R (2011) *Flash flood risk management – A training of trainers manual,* Kathmandu: ICIMOD
17. UNISDR Terminology on Disaster Risk Reduction, 2009. United Nations. Geneva, Switzerland
18. Verifying and Refining GLOF Hazard and Vulnerability Assessments for Community Based Flood and Glacial Lake Outburst Risk Reduction Project (CFGORRP), 2014. Department of Hydrology and Meteorology, Ministry of Population and Environment, Kathmandu, Nepal
19. Vulnerability and Adaptation Assessment: Report for Second National Communication, 2011. ADAPT Nepal and Tribhuvan University

ANNEX 10: Schedule 13: Disaster Management Plan Guidance Note

Disaster management is a systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improve coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster. The Disaster Management Plan should be holistic in approach, recognizing that environmental risks arise from the complex interaction of environmental hazards and socio-economic vulnerability.

1. Objectives

The objectives of the Disaster Management Plan are listed below:

i. Prevention of disasters and their impact on families, infrastructure and environment;
ii. Building resilience of families and communities by reducing their vulnerability and increasing their ability to withstand and minimize the effects of disasters and complex emergencies by enhancing preparedness;
iii. Providing fast, coordinated, effective and appropriate responses to disasters and complex emergencies; and
iv. Ensuring timely recovery from disasters and complex emergencies, and leaving communities and families in a better position to withstand future hazards.

2. Key hazards

The hazards for the Project are partly caused by nature and partly man-made, some are avoidable, others not. Some of the hazards outlined below could cause inundation leading to the loss of lives and properties. Following are the key hazards for the Project:

i. Dam break;
ii. Earthquakes, causing damage to the dam;
iii. Erosion, Landslides into the reservoir causing overtopping of the dam;
iv. Glacial lake outburst flood, GLOF;
v. Extraordinary and untimely floods; and
vi. Emergencies resulting from improper spillway gate operation.

3. Responsibilities

The Company shall have the responsibility for preparing the disaster risk management plan 12 months after the agreement date in consultation with the local authorities for communities likely to be affected by project related emergencies. The disaster risk management plan shall cover the reservoir filling, early operation period and routine operation and maintenance phase. The plan shall provide for the following:

- Provision of warning signs in flood inundation zones previously identified by the Company, areas, for sirens and other alarms when an emergency has occurred or is imminent, for operation of the dam and the spillway in a safe manner for actions to be taken In the event of the occurrence of the key hazards referred to above, and for actions to be taken to mitigate adverse effects if an emergency occurs.
- Notification of previously identified key members of downstream communities with normal responsibility for dealing with civil emergencies. These personnel shall be responsible for liaising with potentially affected communities and for organizing evacuation.
- Education and periodic re-education of local communities by the developer in cooperation with the local government.

The Company shall work in coordination with the relevant government authority to implement the plan in case of an emergency or potential emergency that is primarily attributable to the Company. The Company shall have the responsibility for carrying out remedial works after such an emergency in consultation with concerned government authority.