



## SLOPE STABILITY ASSESSMENT OF LANDSLIDE INCIDENCES ALONG NATIONAL HIGHWAY 108

### Geography

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### ABSTRACT

A disaster may be define as a serious disruption of the functioning of society causing widespread human material and environmental losses which exceeds the ability of the affected society to cope using its owns resources. Landslides play an important role in the evolution of landforms and represent a serious hazard in many areas of the World. In places, fatalities and economic damage caused by landslides are larger than those caused by other natural hazards, including earthquakes, volcanic eruptions and floods. Due to the extraordinary breadth of the spectrum of landslide phenomena, no single method exists to identify and map landslides, to ascertain landslide hazards, and to evaluate the associated risk.

### KEYWORDS

Disasters, Landslides, Hazard, Vulnerability, Mitigation.

### INTRODUCTION

A "landslide" is the movement of a mass of rock, debris, or earth down a slope, under the influence of gravity; Different phenomena cause landslides, including intense or prolonged rainfall, earthquakes, rapid snow melting, and a variety of human activities. Landslides can involve flowing, sliding, toppling or falling movements, and many landslides exhibit a combination of two or more types of movements. The range of landslide phenomena is extremely large, making mass movements one of the most diversified and complex natural hazard. Landslides have been recognized in all continents, in the seas and in the oceans. Mass movements can occur singularly or in groups of up to several thousands. Multiple landslides occur almost simultaneously when slopes are shaken by an earthquake or over a period of hours or days when failures are triggered by intense or prolonged rainfall. The prolonged rains in the catchment of the Bhagirathi and tributaries caused devastating flash floods. Unprecedented discharge from the rivers swept away many of the settlements, commercial and government buildings, communication network and transmission lines, cultivated fields and forest land located on or near the banks of river.

The road network has been severely damaged for kilometres along NH-108 at Dharasu Bend, Naitala, Malla, etc. Many villages such as Joshiyara, Tiloth, New Dedsari, Bhatwari, Kiarak, Barsu, Dharali, etc. in the district have been badly damaged. In the past also Uttarakashi district had experienced many natural calamities like Kanauldia *gad* landslide of 1978, Bhairon Jhanp *nala* landslide at Gangotri in year 2002, Malla landslide of 2008 and Bhatwari landslide of 2010. Apart from these, cloud burst incidences are reported almost every year in higher reaches of trunk stream of the Bhagirathi. In the year 2010 on 17th August a part of Bhatwari township experienced subsidence and sliding, damaging around 38 houses, shops, and around 100m stretch of NH-108, due to heavy downpour in the area. In September 2003, Uttarakashi town, located at the base of Varunavat *Parvat*, on the right bank of the Bhagirathi River, witnessed massive landslide that buried a number of civil structures, including private houses, government offices and hotels. The 6.9 magnitude Uttarakashi earthquake of 20th October, 1991 with its epicenter near Agoda village, Uttarakashi district is the major seismic event recorded in the area under investigation. This event had induced a number of small and large landslides.

### STUDY AREA

The study area falls in parts of toposheet no. 53J/6 and is bounded by latitude N 30°37'53" and N 30°43'31" and longitude E 78°19'43" and E 78°21'34". The area is connected by all weather metallic road. Traverses were taken along NH-108 which leads to famous Hindu Shrines at Gangotri.

The Uttarakashi district is surrounded by Himachal Pradesh and China in the north, Chamoli and Rudraprayag districts in the east, Tehri district in the south and Dehradun in the west. The area forms mountainous terrain characterized by rugged topography and marked by steep slopes and narrow valleys. However, moderate slopes with gentler terrace are also present in the Bhatwari area. The general altitude increases along NH-108 from 955m above msl near Dharasu

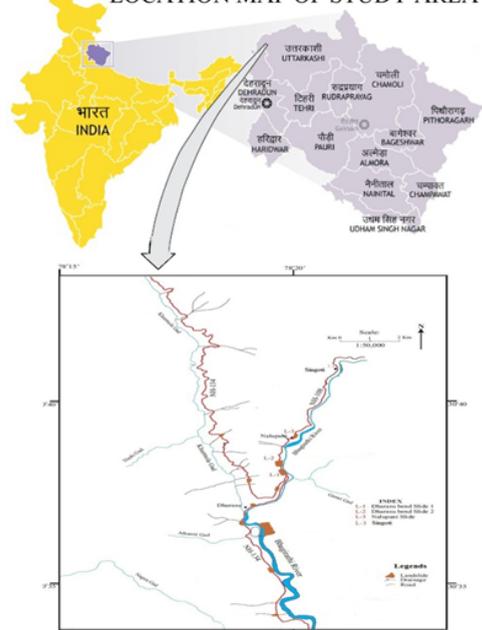
bend southwest of Uttarkashi town to 3049m

Above msl near Gangotri. The southern and south eastern part is drained by the Bhagirathi River flowing southerly along with its tributaries Nagun *gad*, Athuni *gad*, Khurmola *gad*. The study area falls in Zone- IV and Zone-V of the Seismic Zoning Map of India.

### OBJECTIVE AND SCOPE OF WORK

1. Evaluate the causative factors identify susceptible locations of fresh mass wasting and failure.
2. Preliminary assessment for effective mitigation measures for restoration of roads along NH.
3. The scope of the present studies of landslide is to assess the causes, nature and extent of damage And to propose some futuristic plans for the landslide affected areas in respect of their effective and Implementable mitigation measures.

### LOCATION MAP OF STUDY AREA



### REVIEW OF LITERATURE

A detailed description with related to disaster management and it's all aspects are wrote by Satendra IFS, 2003, in his book "Disaster Management in the Hills "especially for hill regions, he cover all aspects like vulnerability, management, government policies etc. in Utrakhand state. R.B.Singh in 2012 wrote in his book "Natural Hazards & Disaster Management Vulnerability and Mitigation" related to conceptual and empirical case studies from India and other

developed countries, understanding with an empirical approach to the disaster vulnerability and mitigation together with monitoring and forecasting and policy perspectives.

Ramkumar described in his book "Geological Hazards" about causes due to which disaster happens, Vulnerability of which vary according to the type and intensity in addition to various other reasons such as topography, slope, soil and litho logy etc. Thus, Hazards, disasters, vulnerability, risk and preparedness are the five terms that need to be understood, thus his book contain individual chapter deal with specific geo-hazards, causes, potential impact and mitigation measures for the understanding of general readers. K.S.Valdiya, 1998,"dynamic Himalaya" wrote about portray a simplified picture of the setting and origin of the Himalaya. D.K.Agrawal at.all. 1997, "perspectives of the mountain risk engineering in the Himalayan region" the theme of book is to explain mass wasting processes and assessment preventive/control measures of wasting processes.

#### Landslide incidences along NH-108 (Dharasu to Gangotri)

No.	Name of the slide/ new or reactivated slide	Latitude/ Longitude	Elevation	Type of slide
1	Dharasu Bend-1 (Reactivated slide)	N 30°37'53.5"/ E78°19'43.6"	±955m	Rock cum debris
2	Dharasu Bend-2 (Reactivated slide)	N 30°38' 07.1"/ E78°19'38.00"	±957m	Rock cum debris
3	Nalupani slide (New slide)	N 30°38' 57.1"/ E78°19'56.8"	±1013m	Rock slide
4	Singoti (New slide)	N 30°43' 31.1"/ E78°21'34.4"	±1030m	Debris slide

#### METHODOLOGY

Information about the area is collected from Primary and Secondary sources in order to analyze the present scenario of Government and other concern authority's for their approaches to mitigate landslides. Besides literature, Maps, Aerial photographs, Satellite imageries is used. GIS and Remote Sensing Technique is used for study and making of study area map.

#### 1. Dharasu Bend Slide-1

The slide is located near Dharasu Bend on national Highway No-108, elevation at road level is ±955m, This is a rock cum debris slide. It is an old slide which reportedly got initiated in year 2008 and again got reactivated between 15th and 17th June 2013. This slide is located near the point of bifurcation of NH-108 (leading to famous Shrine Gangotri) and NH-134 (leading to Yamnotri Temple). During every rainy season it frequently blocks the strategically important road which reaches up to China border. Due to road widening activities the toe of the slide got disturbed and jointed and fractured rock mass got saturated during heavy and continuous rains between 15th and 17th June 2013. After saturation the unconsolidated slope wash material started sliding down the steep slope under the influence of gravity.

Short term stability measures are as under;

- Removal /unloading of the head and modification of the slope by providing berms in between and Protection of the slope through wire mesh and concreting in rocky portion and biodegradable treatment in the slope wash material.
- Well designed retaining wall with adequate number of weep holes as rock is exposed at the outer edge Of the road.
- Construction of breast wall all along the road with weep holes at suitable interval in the affected area.
- Divert the flow of surface run-off from the crown away from affected zone and in between the Slope catch and cross drain along with lined toe drain should be provided.

#### 2. Dharasu Bend Slide-2

The slide is located near Dharasu Bend on NH-108, elevation at road level is ±957m, and this is an old slide which got initiated in the year 2008 and again got reactivated between 15th and 17th June 2013. The already disturbed toe during road widening slid down after getting saturated during heavy rains. This location is close to the slide no.1 towards Uttarkashi and the remedial measures suggested below are almost the same as slide 1.

- Modification of the slope by providing benches followed by wire

mesh /chain link and concreting on Selected slope reaches.

- Retaining/ breast wall with adequate number of weep holes at suitable interval.
- Lined toe drain all along the road with proper gradient away from the affected area.
- For permanent solution detailed geological mapping on 1:5000 scale and geotechnical assessment is needed and on the basis of geotechnical assessment/ inputs realignment or possibilities of tunnel May be considered.

#### 3. Nalupani Slide

The slide is located about 200m before Nalupani gad on NH-108, elevation at road level is ±1013m, The area is occupied with mainly white to buff colored coarse grained moderately jointed quartzite with bands of green colored, medium grained basics rocks of Garhwal Group. This is a rock slide in which huge blocks of white to buff colored quartzite has slid down due to disturbance of toe during road widening activities. The already disturbed mass got saturated during heavy spell of rains between 15th and 17th June 2013 resulting in planar and wedge failure. The slid material includes huge blocks of quartzite which in general are hard and compact, though, at places the rock mass is weathered. Following are the immediate remedial measures for restoration of the damaged highway.

- Road widening activities should be done in planned way by adopting controlled blasting pattern and
- The disturbed slope should be immediately support by retaining wall, breast wall and wire mesh concreting etc.
- Removal of loose detached and overhanging rock blocks carefully in planned way to avoid further Sliding/ blockage of road.
- The exposed surface should be immediately protected with chain link.
- Stitching of the vulnerable joint planes with rock bolts at an angle to foliation plane.
- Constructing well designed retaining/ breast wall with weep holes at suitable interval.

#### 4. Singoti Slide

The slide is located on NH-108 near Maharshi Vigyan Vidhya Peeth School, elevation at road level is ±10360m, toposheet number 53J/6) on the right bank of Bhagirathi River. They are occupied by river borne material and Bhagirathi river is being used for cultivation. It was a flat terrain and the national highway was passing towards outer edge of the cultivated land. The slide is initiated due to heavy and continuous rains between 15th to 16th June 2013 which caused flash floods in Bhagirathi River and due to sudden increase in discharge of Bhagirathi river, the river shifted its course (encroaching 50m towards right side) and eroded the right bank and caused toe cutting of the unconsolidated river borne material (~35m terrace height) which washed away steep terrace including ~275m stretch of NH-108, one Ashram located on the right bank at river bed level and partially damaged one hotel (Narayan Hotel) which is located on the same bank but at higher level. The cultivated land is showing gaping, subsidence cracks towards free face. Temporarily restoration of the road has been done by the Border Road by cutting hill slope however, for permanent solution following are the recommendations:

- Restoration work by the concerned agency has been done but it is not feasible because of the high gradient and initial stretch of the road is again towards river side which is prone to sliding during Rainy season.
- Realignment of the road towards hill side leaving >50m stretch as buffer zone towards river side.
- The initial 100m stretch of the road which is quite steep it should be made by cutting road carefully much before damaged portion.
- In addition to the realignment of road river bank protection is essential as the flow of Bhagirathi is Completely shifted towards right bank therefore, well designed RCC retaining wall.
- In view of the safety the part of the hotel complex should be vacated or shifted in safer place near by the area.

#### CONCLUSIONS

The main factor responsible for triggering of the landslides are abnormal downpour causing flash floods, toe cutting, saturation of slope forming material. Also, anthropogenic activities like road cutting, encroachment of human in the river/ nala bank and unplanned urbanization, etc have aggravated the situation. Slope failures have

mainly occurred due to over saturation of debris material after incessant rains. The slopes occupied with unconsolidated slope wash, river borne material (terrace), jointed, weathered and shattered rock mass should, in general, be protected from water charging water logging and surface runoff should be channelized by constructing contour drains, catch drains and lined toe drain with proper gradient depending on site geology and topography. The slope with gentle slope angle and occupied with highly weathered rock mass can be stabilized by giving biodegradable treatment like geo-jute / geo-net along with mulching of local species of grass and bushes. Construction of breast wall/ retaining wall along with adequate number of weep holes/perforated pipes for draining out water thereby reducing the pore water pressure is recommended. For landslides caused due to toe cutting/erosion by the river, proper toe protection measures have to be adopted like constructing RCC/ retaining wall with deep foundation either on the sound bed rock or it should be lowered down below the depth of river/ nala as per site geological or topographical conditions.

Construction of roads in such areas be planned carefully and excavation and stabilization work should be done concurrently, backfilling of the constructed wall should be done with proper compaction and providing lined toe drains, etc. Drainage system improves life of structure because water is the main culprit as happened at Dharasu landslide.

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