आज़ादी का अमृत महोत्सव

सत्यमेव जयते

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ARCHIVAL RECORDS AND DOCUMENTATION OF SOCIO-ECONOMICALLY SIGNIFICANT LANDSLIDES IN INDIA



KINNAUR LANDSLIDE



SUMGARH UTTARAKHAND



KERALA LANDSLIDE



LANDSLIP IN SHIMLA

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Resilient India - Disaster free India

National Institute of Disaster Management (NIDM)
(Ministry of Home Affairs, Government of India)

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ताज हसन, भा. पु. से.
कार्यकारी निदेशक

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सत्यमेव जयते
आज़ादी का अमृत महोत्सव

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Foreword

The severe landslide hazard vulnerability of the mountainous states and other parts of the country is indubitable. India has witnessed several horrendous landslide disasters which have hampered socio-economic development and growth besides losses to lives, livelihood, environment, structures and infrastructure. To learn from such disasters and to bring about manual for efficient mitigation practices, a comprehensive, multidisciplinary and integrated documentation approach of activities is needed.

In pursuance of the mandate of DM act 2005, and for documentation of landslides, NIDM developed a record of some noteworthy socio-economically significant landslides in India for training and policy advocacy purposes. This may be used as the learning module, particularly for case studies in Landslide Risk Management. It has been prepared by Dr. Surya Parkash, Professor and Head, GMRD, NIDM, Ms. Dipali Jindal, Mr. Anil Kathait and Mr. T. K. Saha Roy, Jr. Consultants, NIDM based on their several years' experiences in organizing and coordinating multiple training programmes on landslides.

I also express my gratitude for the sincere and professional inputs from the external reviewer in assisting the NIDM in the formulation of this archival record.

Hopefully, the document will help disaster management authorities and other relevant stakeholders in finding the gaps in current scenario, and making strategies to avert or reduce the impacts of such catastrophic events.

tajhassan

(Taj Hassan)

Resilient India - Disaster free India

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Preface

Landslides have been a frequent, widespread and often sudden phenomenon in hilly terrains, particularly during the rainy season of the monsoon period. Most of the landslides are triggered by incessant prolonged precipitation or high to very high intensity rainfall or extreme weather events like cloudbursts. The landslides have also occurred due to earthquakes, blasting, explosion, mining, deforestation, landuse and land cover changes, drainage blockade, lake outburst, toe erosion or scouring action by the rivers and their tributaries, slope modificatins, ill planned construction and developmental activities as well as other human interventions etc.

The landslides pose threat to the human lives, livelihood, living places, livestock, resources, infrastructures, utilities, services and the ecosystem in the affected areas. History of landslides is an important aspect for understanding the likelihood of its occuurence along with maginitude and impacts. A study of historical archival records of such landslides can help decipher the lessons learnt from the past incident through identification and assessment of what went and what right in the pre, during and psot disaster situations. The significant landslides data has been missed as there has not been much systematic efforts to compile and update the information on these events. Hence, an attempt has been through IPL Project-233 and an In-house project on Archival Records and Documentation of Some Socio-economically Significant Landslides in India, done by the World Centre of Excellence on Landslide Disaster Reduction (conferred by by the Global Promotion Committee of the International Consortium on Landslides and International Programme on Landslides International Strategy for Disaster Reduction) at NIDM. The document provides archival records of socio-economically signficant landslides in India along with information related to locations, date/ duration of events, impacts and lessons learnt.

In this document, landslides have been classified based on their level of socio-economic siginificance as low, moderate and high significance categories. The study has identified 412 socio-economically significant landslides that have been briefly discussed in this document including Nashri landslide, Khuni Nallh landslide, Malpa Rock avalanche, Kaliasaur Landslide, Sher ka Danda, Snowdon landslide, Marappalam landslide, Amboori landslide, Varunavat Parvat landslide, Munsiyari landslide, Kapkot landslide, Aizawl Landslide, Kinnaur landslide and many more.

It is hoped that the document will provide an insight to the concerned stakeholders and communities about the landslides incidents, impacts and lessons learnt to pave the way forward for landslides risk reduction and resilience in the country.

(Surya Parkash)

Acknowledgement

At the outset, I would like to express sincere thanks to Shri Taj Hassan, Executive Director, National Institute of Disaster Management, New Delhi for his kind encouragement in writing this module. Thanks are also due to Shri Surendra Thakur, Joint Director, NIDM for his kind support during the preparation and publication of this document. I would like to place on record my heartfelt thanks for the significant contributions made by different resource persons in compiling the information, database and maps related to landslides in the country.

Sincere thanks are due to Shri Sanjeev Sharma, Former DDG, Geological Survey of India and Dr. Ravinder Singh, Senior Consultant (Landslides and Avalanches), NDMA for reviewing the document.

I would like to express gratitude to all my colleagues including Ms Dipali Jindal, Mr Anil Kathait and Mr T.K. Saha Roy, Dr. Harjeet Kaur, Dr. Raju Thapa, Dr. A.L. Haldar, Shri Hari Hara Kumar Devada, Mr. Ajit Batham, Mr. Gunda Goutham Krishna Teja who have extended all the crucial support and cooperation for the preparation of the archives on landslide in India.

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Last but not the least, I would like to thank my wife Reeta and my daughter Rasika, without whose consistent moral and logistic support, I would not have been able to give due attention and time to this work. I am indebted for their tolerance to bear with me when I was busy with work related to the module and could not give due attention and care to them.

Finally, I am grateful to the Almighty God without whose grace and kindness, I would not have been capable to carry this task successfully.



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Executive Summary

The World Centre of Excellence on Landslides Disaster Reduction at NIDM Delhi carried out a short-term study (9 months period) on the documentation of the landslides disasters to prepare brief archival records of the socio-economically significant landslides in India in order to bring out the lessons learnt from these events. About 12.6% of the country's land territory is affected by landslides of varying nature, dimensions and degree of severity in terms of damages and losses incurred by them. Approximately 70,000 landslides across >65,000 villages of about 19 States and Union Territories, have been reported through landslides inventory mapping by different institutes and organizations within the country. However, the data on landslides disasters is still considered to be scarce and incomplete as few systematic studies have been done to compile the historical database to understand their socio-economic importance and environmental implications. The documentation of socio-economically significant landslides through the archival records would have helped in understanding the cumulative impacts over a period of time within a given space and also in assessment of actions taken to decipher what went wrong and what went right during those events.

Keeping the above in mind, the Institute initiated an in-house project (Duration: 9 months) to prepare an archival record of the socio-economically significant landslides in India and to document the lessons learnt from such incidents. The major challenges faced during the study included the criteria to be used for identifying and classifying the socio-economically significant landslides from the existing landslides inventory database available in different forms like research papers, reports, news archives, media channels, office records etc. from the various relevant institutes and organizations. The existing information has been found in different formats with variable nature, depending upon the purpose for which it was actually acquired. NIDM developed the essential criteria to identify and classify the socio-economically significant landslides based on the impact parameters and also documented the lessons learnt from these landslide disasters considering the recommendations or suggestions made by the concerned experts / organizations during these landslide incidents.

The study revealed 412 socio-economically significant landslides from the year 1868 to 2022, that have adversely affected the human lives, livelihood, living places, livestock, resources, economy, infrastructure and the ecosystem with different degrees of the severity, Based on the proposed criteria and classification under this study, 183 landslides fall under low socio-economic significance category while 89 in the moderate and 140 landslides fall in the high socio-economically significant landslides. The data of these landslides has been gathered from the various sources including Geological Survey of India, Department of Geology and Mines in the States, Public Works Departments, Emergency Operation Centres, Disaster Management Authorities, Revenue and Disaster Management Departments, Statistics and Planning Departments, Soil and Water Conservation, Space Application Centres, Media Reports, News Archives, Academic and Research organizations etc.

The key lessons learnt from the present study can be briefly listed as below.

- The drastic change in precipitation, glacial melts, river water levels, drainages and sewerage water conditions can lead to water related landslide disasters.
- Seismic vibrations, quarrying, mining, blasting, explosion and deforestation in landslide susceptible areas may cause slope failures. Hence, appropriate planning, design, construction and maintenance are necessary for buildings and infrastructure resilience.
- Landslides dammed lake outburst floods may result in heavy sedimentation, rise in river bed levels and damages / losses to different elements in the downstream areas.
- Enforcement of mountain zone regulations, building bye laws, techno-legal regimes and adequate construction practices with proper storm water run-off and drainage / sewerage facilities is important for land use planning, slope modification and landslides risk reduction and resilience. Avoid encroachment in landslide susceptible areas and remain vigilant for illegal unscientific unplanned construction activities.
- Climate change adaptability and sustainable development in the hilly terrains must be promoted for safety, risk reduction and resilience against landslides.
- Avoidance, Prevention and Mitigation for the potential / existing landslides to minimize the damages and losses. Impending critical landslides must be monitored and an early warning system should be ensured. Toe erosion / scouring actions by the river and its tributaries should be prevented or minimized through embankments, spurs and levees.
- Remediation, Response, Rehabilitation and Recovery plans for the impending landslide threats need timely implementation.
- Community based disaster risk reduction and resilience may be encouraged through awareness, information and preparedness at the local levels. Tourism, trekking, pilgrimage and other such activities must be kept under control depending upon the carrying capacity of the area.
- Systematic scientific documentation of socio-economically significant landslides should be continued and maintained through-out the history of landslides in any area. Establish best practices for landslides management and demonstrate it through environment friendly human settlements / activities with least landslides hazards / risks. Rethink about necessary modifications in policies, plans, regulations, procedures and practices for landsides risk reduction and resilience

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Who Shall Use This Book Compilation?

This can be used by the disaster management authorities and other relevant stakeholders in finding the gaps in current scenario and the strategies to be adopted to reduce the impacts of such catastrophic events. The following individuals/organizations are considered potential users of this document:

- Geologists, Civil/Mining/Hydel Project Engineers, Field Professionals, Architects/ Planners, Developers, Environmentalists etc. studying/working in Hilly Terrains
- NDMA, SDMAs, DDMAs
- Geological Survey of India, State Departments of Geology and Mines, Academicians, Researchers and Professionals working on landslides
- Disaster Management Centres at State ATIs & SIRDs
- NGOs, CBOs, SHGs, Social Volunteers, Public Representatives
- NDRF, SDRF, QRTs, RRFs, paramilitary departments and Indian Army
- People from Administration, Local Bodies like Municipality and Panchayats
- NSS, NYKS, NCC, Scouts and Guides, Home Guards, Civil Defence and Fire Fighters
- Field Agencies like Border Roads Organization, CPWD, State PWDs, NHAI, PGCL, NHPC, THDC, NTPC, Irrigation and Flood Control etc
- Stakeholders in Insurance, Finance, Planning, Policy making and those engaged in Development and Legal Sectors

Abbreviations / Acronyms Used

ATES	Advanced Technical Engineering Services
ATI	Administrative Training Institute
BIS	Bureau of Indian Standards
BRO	Border Roads Organization
CBDP	Community Based Disaster Planning
CBLRM	Community Based Landslides Risk Management
CBDRM	Community Based Disaster Risk Management
CBO	Community Based Organizations
CBRI	Central Building Research Institute
CLRM	Comprehensive Landslides Risk Management
CRF	Calamity Relief Fund
CRRI	Central Roads Research Institute
DDMA	District Disaster Management Authority
DGBR	Director General Border Roads
DGCD	Director General Civil Defence
DGM	Department of Geology and Mines
DMA	Disaster Management Act
DMMG	Department of Mines, Minerals and Geology
DoS	Department of Space
DST	Department of Science & Technology
ESF	Emergency Support Function
GREF	General Reserve Engineering Force
GSI	Geological Survey of India
GFDRR	Global Facility for Disaster Reduction and Recovery
HVCR	Hazard, Vulnerability, Capacity and Risk
ICL	International Consortium on Landslides
ILC	International Landslide Centre
IMD	Indian Meteorology Department
IIRS	Indian Institute of Remote Sensing
IPL	International Programme on Landslides
ISDR	International Strategy for Disaster Reduction
ISRO	Indian Space Research Organization

ITBP	Indo Tibetan Border Police
LHZ	Landslides Hazard Zonation
LMP	Landslides Management Plan
LRM	Landslides Risk Management
LSN	Landslides Schools Network
MHA	Ministry of Home Affairs
MoM	Ministry of Mines
MoES	Ministry of Earth Sciences
NCCF	National Calamity Contingent Fund
NDMA	National Disaster Management Authority
NDMRC	National Disaster Mitigation Resource Centre
NDRF	National Disaster Response Force
NDRF	National Disaster Response Fund
NGO	Non-Governmental Organization
NHAI	National Highway Authority of India
NHPC	National Hydro Power Corporation
NIDM	National Institute of Disaster Management
NTPC	National Thermal Power Corporation
NRSC	National Remote Sensing Centre
PGCL	Power Grid Corporation Limited
PWD	Public Works Department
QRT	Quick Response Team
SASE	Snow and Avalanches Studies Establishment
SDMA	State Disaster Management Authority
SDRF	State Disaster Response Fund
SDRF	State Disaster Response Force
SOP	Standard Operating Procedures
THDC	Tehri Hydro Development Corporation
UNDP	United Nations Development Programme
USGS	United States Geological Survey
VOs	Voluntary Organizations
WBI	World Bank Institute
WIHG	Wadia Institute of Himalayan Geology

1. INTRODUCTION

1.1 DEFINITIONS AND TERMINOLOGY

The definitions of some of the key terms commonly used in the field of disaster studies are presented below:

Disaster - A serious disruption of the functioning of society, causing widespread human, material, or environmental losses, which exceeds the ability of affected society to cope using its resources.

Elements at Risk - Population, buildings and engineering works, economic activities, public utilities, other infrastructure, and environmental values in an area affected or potentially affected by a landslide.

Hazard - A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Vulnerability - The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

Risk - The combination of the probability of an event and its negative consequences.

Mitigation - The lessening or limitation of the adverse impacts of hazards and related disasters.

Natural Hazard - Natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Capacity - The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals.

Capacity development - The process by which people, organizations, and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through the improvement of knowledge, skills, systems, and institutions.

Figure.1 illustrates the relationship of vulnerability, capacity, hazard, disaster w.r.t risk.



Figure 1: Relationship among disaster related elements

1.2 BACKGROUND

In recent times, there has been an increase in the frequency and spread of natural or man-made disasters in India, with landslides topping the list. Landslides are a major geological hazard, which present a serious threat to the human population and various other infrastructures such as roads and railroads and civil structures such as dams, buildings and other structures in hilly areas. These geohazards are also known as cascading events during other major hazards, such as earthquakes, floods and volcanoes. To minimize the geo-environmental hazards, it's very important to study in detail the past events that occurred. It is important to have an updated landslide inventory as the list is the basis for assessing the vulnerability, hazard and risk of landslides (Soetets, 1996); (Aleotti, 1999); (Ardizzone, 2002). Though, a significant amount of literature on the study & characterization of landslides is available, yet none of the these discusses the socio-economic effects of landslide hazard. Landslides are one of the most widespread hazards on the Earth and cause thousands of deaths and injuries and billions of dollars in damage worldwide each year. Statistics from the Centre for Research on the Epidemiology of Disasters (CRED, http://www.cred.be/) show that landslides contribute about 17% of total fatalities due to natural hazards. It is hard to calculate actual values for the socio-economic impact of landslides because the landslide hazard assessment is often merged with other associated natural disasters such as earthquakes, floods, meteorological events and is not differentiated as a separate hazard. This consequently reduces the concern of individuals and officials about the gravity and risk of landslides.

In India, qualitative & geoscientific information to minimize loss of life and damage to property from landslide hazards are maintained by Geological Survey of India (GSI), the nodal agency for landslide studies. In year 2014-15, GSI launched a national programme on landslide susceptibility mapping on macro scale (1:50,000) National Landslide Susceptibility Mapping (NLSM) to cover the 0.42 million sq. km landslide-prone area of the country. GSI, has already mapped 3.57 lakh km^2 area (85% of the total target) Figure 2. This map shows the progress of the NLSM program.

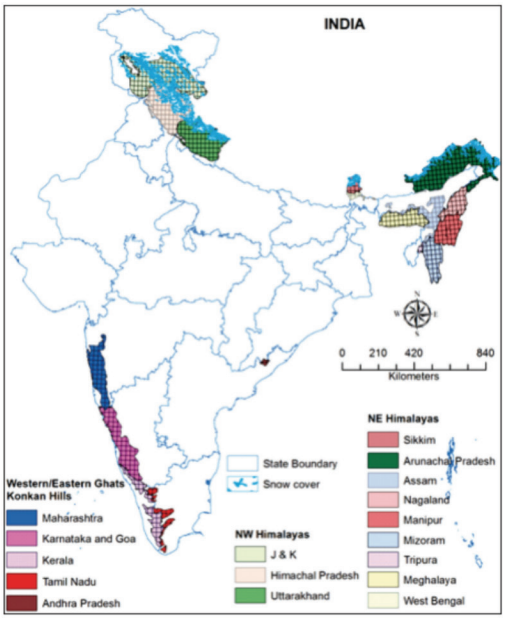


Figure 2: Progress of NLSM programme (Source : NDMA, 2019)

It's evident from Figure 2 that landslides affect large parts of India, especially the Himalayas, the Northeastern hill ranges, the Western and Eastern Ghats, the Nilgiris and the Vindhyas. About 15% of Indian terrain is vulnerable to landslide hazards. Out of this, 80% is spread over the Himalayas, Nilgiris, Ranchi Plateau and Eastern and the Western Ghats and the rest in the northeastern region. Over the past several decades, slope failures have caused untold numbers of casualties and enormous economic losses. As reflected in the global landslide dataset, most of the landslides in Indian Himalayan region are rainfall triggered. The Indian Himalayan region is one of the most diverse and heterogeneous area in terms of geology, geomorphology lithology, rainfall distribution, land use/land cover, soil properties and road and stream networks, which makes it highly prone to landslides. The region covers 16.2% (~500,000 km^2) of India's landmass as well as 10 of its states (Ministry of Environment, Forest and Climate Change, Government of India). The region extends from 26°20'N 74°50'E to 35°40' N 95°40' E and covers the states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Meghalaya, Nagaland, Manipur and Mizoram, as well as hilly regions of Assam and West Bengal. The region has been divided both horizontally and vertically into four and three divisions, respectively. In horizontal context, it has been categorized as Jammu and Kashmir Himalaya, Himachal Himalaya, Uttarakhand Himalaya and Eastern Himalaya (Figure 3). Thus, in order to understand the impact of landslides in terms of their socio-economic perspective, it is necessary to have a criterion that can further form a separate inventory of the same. In the subsequent sections, the criteria and list of selected landslides are dicussed. Figure 4 shows the inventory of the documented landslides on the map of India.

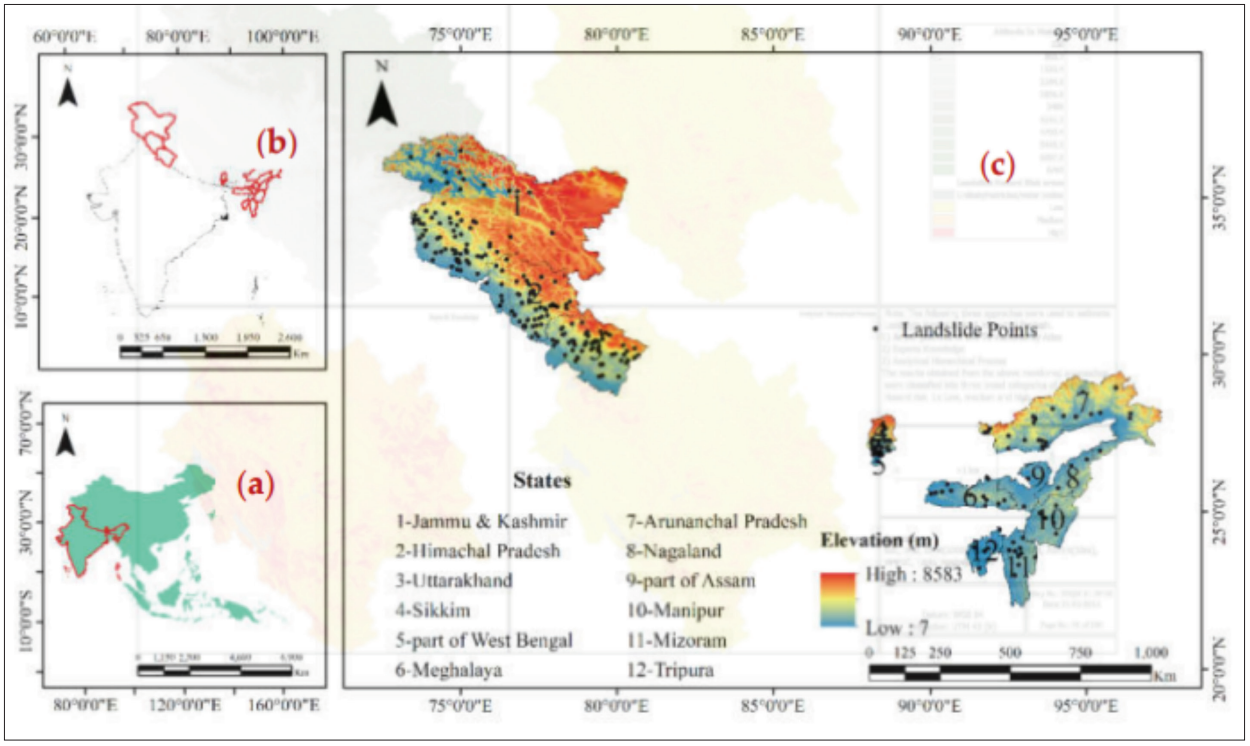


Figure 3: (a) Southeast Asia highlighting India; (b) Geographical boundaries of India highlighting the Indian Himalayan region; and (c) Location of rainfall-induced landslides in the Indian Himalayan region [1] (DEM Source: SRTM, resolution 30 m) (Source : Dikshit et al. 2020)

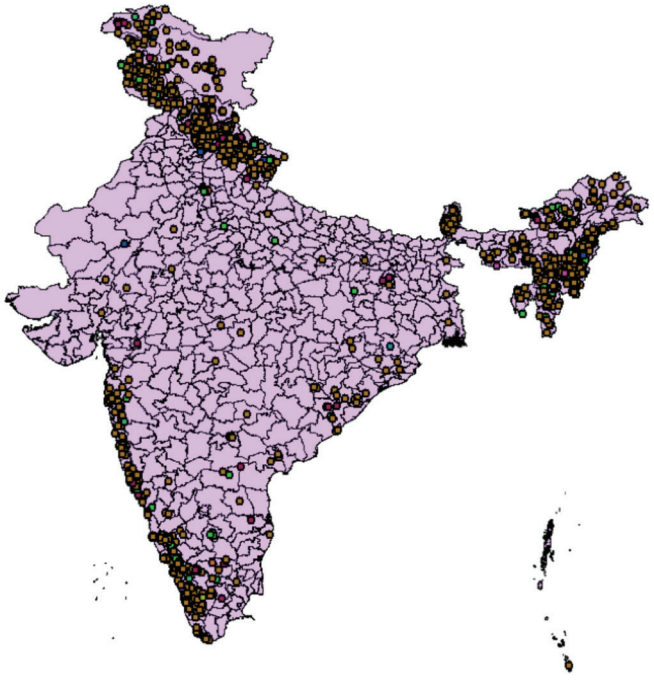


Figure 4: Types of documented landslides on the map of India

1.3 PERSPECTIVES OF SOCIO-ECONOMIC LEVELS IN DISASTER

The impacts of a disaster are categorized into two parts i.e., physical and social impact. The physical impacts of a disaster are usually the casualties (deaths and injuries) and property damage, easily measured, and first reported by the news media. Whereas, psychosocial, demographic, economic, and influences, which can develop over a long period and be difficult to assess, are classified under social impacts. Despite the difficulty of measuring these social impacts, it is also important to monitor and, if possible, predict them, as they can cause significant problems for the long-term functioning of specific types of households and businesses in the affected community.

In addition to the physical impact, disasters do affect the economic sector as well. The impact on the economy varies from place to place depending on whether affected areas are heavily industrialized or not, several people might have lost their livelihoods or not, the tourism sector suffered heavy losses due to cancellations and lost assets or not. The report titled *Economic Losses, Poverty and Disasters 1998-2017* was compiled by the UN Office for Disaster Risk Reduction. It states that in the last 20 years, India has suffered a huge economic loss of 79.5 billion US dollars due to climate-related disasters. As per the Sendai Framework for Disaster Risk Reduction 2015-2030 it is necessary to invest in the economic, social, health, cultural and educational resilience at all levels. Amid these levels, this document only focuses on the **"social and economic aspect"**.

The effect of a disaster on people, buildings and society is referred to as the impact. The impact of a disaster can, however, be much farther reaching. Wider impacts include longer-term social and economic effects, for example in education, health, productivity or the macro-economy. The impact of disasters can also generate gains, and not only losses, for some people and economies, for example, the demand for construction material and expertise following a disaster can prosper construction

industry. It is therefore necessary to think of disasters in terms of both impacts and losses (Adapted from Understanding Risk: Evolution of Disaster Risk Assessment (GFDRR, 2014); the UNDRR Global Assessment Report 2015 and Prevention Web).

Most incidences of death and injuries take place during the time of occurrence of the actual disaster and are followed by casualty/enhancement of injuries due to inadvertent delay in providing the much needed immediate response and relief measures (because of remoteness, disrupted transportation means and adverse weather conditions), disease outbreaks and shortage of potable water, food and medical care.

Other than this killing people and animals (both livestock and wildlife), disasters destroy or damage residential and industrial development as well as agriculture and negatively affect water quality in forest land and rivers and streams (Highland, 2001).

The terms “damage” and “loss” are often used interchangeably. In the context of disaster loss datasets, losses are expressed in either monetary terms (e.g., market value, replacement value) for physical assets or counts such as number of fatalities and injuries, hence are a quantifiable measures. Whereas, damage is a general term, which is not necessarily quantified, although it does not mean that damage cannot be measured and expressed in terms of loss. For example, a partially damaged house can be expressed in monetary terms (repair cost), which in turn can be included in the loss dataset. Losses are generally divided into two categories i.e., direct and indirect.

According to the United Nations Office for Disaster Risk Reduction (UNISDR): “Direct losses refer to damage to human lives, buildings, infrastructure, and natural resources. Indirect disaster losses are declines in output or revenue, as a consequence of direct losses or owing to impacts on a supply chain” (GAR, 2015).

Whenever a disaster happens it leads to immediate and delayed losses, i.e. direct and indirect losses. Direct losses refer to the physical or structural impact caused by the disaster such as the destruction of infrastructure caused by the force of high winds, flooding or ground shaking. Indirect effects are the subsequent or secondary results of the initial destruction, such as business interruption losses. (Prevention Web).

Many times it’s difficult to quantify the losses such as the destruction of livelihoods, social trauma by a disaster is a direct loss, although quantifying the value of such loss may arguably be difficult. These are sometimes known as 'intangible losses'. As a consequence, disaster loss databases rarely account for psychological (post-traumatic stress), cultural, and environmental (contamination of drinking water, saltwater intrusion, etc.) impacts.

Therefore, to assess disaster risk, it is important to account for disaster losses. Historical losses allow us to develop trends, specifically on the hazards that occur frequently. *While historical losses can explain the past, they do not necessarily provide a good guide to the future*. (UNDRR, 2015a).

1.4 DIFFICULTIES IN DETERMINING LOSSES

Much of the loss data does not account for the smaller, frequent disasters associated with extensive risk. In the recent past, landslides are one of the most frequent disasters. Often evaluation of costs of small landslides can be made, but the quantification of the total assessment of losses due to major landslides covering a large area is a very difficult proposition.

"In the public sector, accounting for landslide costs is often lost within general maintenance operations; this seems to be particularly common for transportation agencies. To separate landslide costs is in itself a costly and complicated operation. In the private sector, the costs incurred by natural hazards are often downplayed as much as possible to minimize negative publicity for the company involved" (Highland, 2001).

According to the literary survey conducted, it can be said that in India, there seems to be a clear lack of a landslide catalogue database in terms of socio-economic importance.

For this reason, the Geo-Meteorological Risk Management Division, National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Government of India has defined socio-economic criteria as shown in table-1 for landslides in India. This work amasses a set of studies with the aim:

1. To collect and compile a database on significant landslides in India.
2. To study and document important relevant information on socio-economically significant landslides from the archival records.
3. To prepare and develop brief case studies on some selected events, impacts, actions/inactions and lessons learned from these landslides.
4. To publish the outcomes of the study and to use it as a knowledge resource for capacity enhancement on landslides risk reduction and resilience.

The estimation should usually begin with an assessment of the number of fatalities, injured, homeless as well as the population affected by the disaster followed by the identification and analysis of damage and losses to the economic sector and infrastructure. The ultimate objective of the evaluation method is to measure the impact of disasters on society, the economy in monetary terms and the environment of the affected states/districts/villages/blocks.

The review was undertaken by carrying out a bibliographic search on the "Web of Science" Database 1990-2021 for a combination of keywords: "Landslide", "Himalaya", "socio-economic", "significant," "economic loss", "rerouting of traffic" and "India". For the current analysis, that is, compilation of archival records, majorly peer-reviewed journal articles were considered, as such journals have the best quality articles. In addition, due to the lack of documentation/availability of some landslides, taking into account news reports also.

In formulating the present document as many as 75 journals were consulted and as per an exercise it was noted that nearly 60% of the landslide events of Indian Himalayan region are contained in just 11 journals (Figure 5). It also emerged that earlier the articles were published only in Engineering Geology and Geomorphology journals. But in recent years the focus is seen to have shifted to other journals as well, namely Natural Hazards, Landslides, Geomatics, Natural Hazards and Risk evaluation and management. Besides the above, Current Science also contains accounts on some major landslide events, but in those write-ups, only preliminary aspects are covered; extensive analysis of landslide study does not figure in these reporting (modified after Dixit et al. 2020).

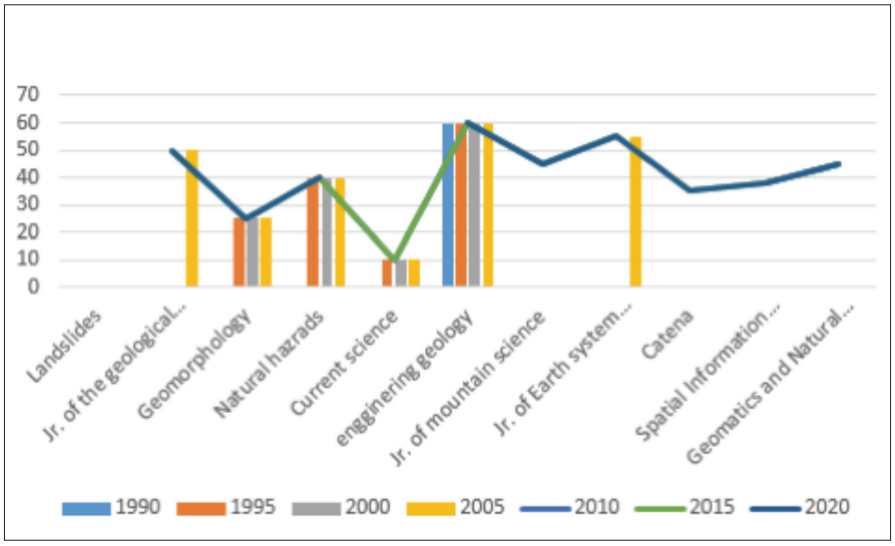


Figure 5: Distribution of the number of articles across the top 11 journals (out of 75) (Source : modified after Dikshit et al. 2020)

The analysis reveals that the landslide studies in the region are quite biased towards Uttarakhand region, as there are no or very few or studies in the northeast Indian region.

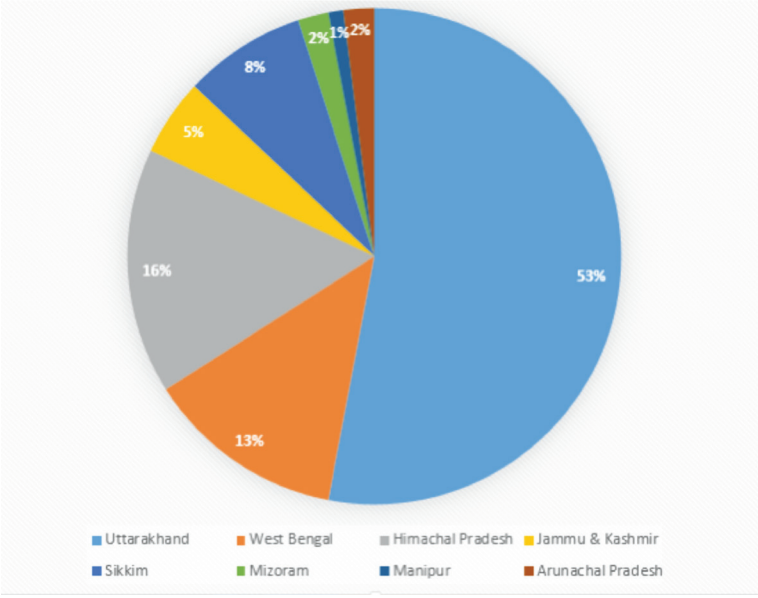


Figure 6: Distribution of landslide studies across states in the Indian Himalayan region (Source : modified after Dikshit et al. 2020)

Based on the range of the socio-economic damages incurred, the socio-economic class of landslides is categorized majorly into Low, Moderate and High. In the present module, the authors have recorded 412 landslides from the secondary data which was extracted from Reports/Interviews, Published Documents, News items, Research publications, Inputs/Communications from Govt. Departments, NGOs/ Community Groups, Survey inputs, Academic/Research Institutes etc. as shown in ***Annexure-A***.

Also, based on the distribution as mentioned in Figure 4 few case studies are being discussed in subsequent sections of this document in terms of their impact, action taken and recommendations, and lessons learnt.

1.5 CRITERIA FOR DEFINING SOCIO-ECONOMIC IMPACT OF LANDSLIDES

TABLE 1: CRITERIA FOR DEFINING SOCIO-ECONOMIC IMPACT OF LANDSLIDES

Low	Moderate	High
Number of human casualties: 1-5	Number of human casualties: 6-10	Number of human casualties: > 10
Number of injured people: 1-10	Number of injured people: 11-20	Number of injured people: > 20
Number of homeless people: 1-15	Number of homeless people: 16- 25	Number of homeless people: >= 25
Population affected: 1-100	Population affected: 101-199	Population affected: >200
*Economic damage & loss: 1-5 Million (INR) [67,837.10 United States Dollar (USD)] (As per 20 Sep, 2021; 1 USD = 73.71 Indian Rupee)	*Economic damage & loss: 5-10 Million (INR) [67,837.10 United States Dollar (USD)] (As per 20 Sep, 2021; 1 USD = 73.71 Indian Rupee)	*Economic damage & loss: >10 Million (INR) [1,35,689.80 (USD)] (As per 20 Sep, 2021; 1 USD = 73.71 Indian Rupee)
**Gross State Domestic Product Loss: 0.5- 1%	**Gross State Domestic Product Loss : 1%- 2%	**Gross State Domestic Product Loss :>2%

*Includes any direct physical damage or a direct net loss. **Current currency rate needs to be considered, i.e., the day when the disaster happened. If a landslide event qualifies any of the above listed in subcategories under the three criteria (Table-1), it can be classified accordingly either under low, moderate, or high class of socio-economic significant landslide event.

State GDP is estimated by the Directorate of Economics and Statistics (DES) in the States, but these are adopted by Central Statistical Organization (CSO) only after verification. Probabilities of human and economic loss are important elements of risk, and nothing captures such losses better than demography and GDP.

Out of 412 landslides (Annexure-A), 183 have been classified as of low socio-economic impact, 89 as moderate and 140 as high.

TABLE 2: NO. OF SOCIO-ECONOMIC SIGNIFICANT LANDSLIDES

LOW	MODERATE	HIGH
183	89	140

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2. DETAILED DOCUMENTATION

2.1 UTTARAKHAND

Uttarakhand is vulnerable to and has been devastated repeatedly by a number of hazards that include earthquakes, landslides, flashfloods, drought and avalanches. These have inflicted heavy loss of human lives, infrastructure, property and other resources. Even though it is not always possible to prevent the occurrence of natural hazards, with effort and planning it is possible to reduce their impact.

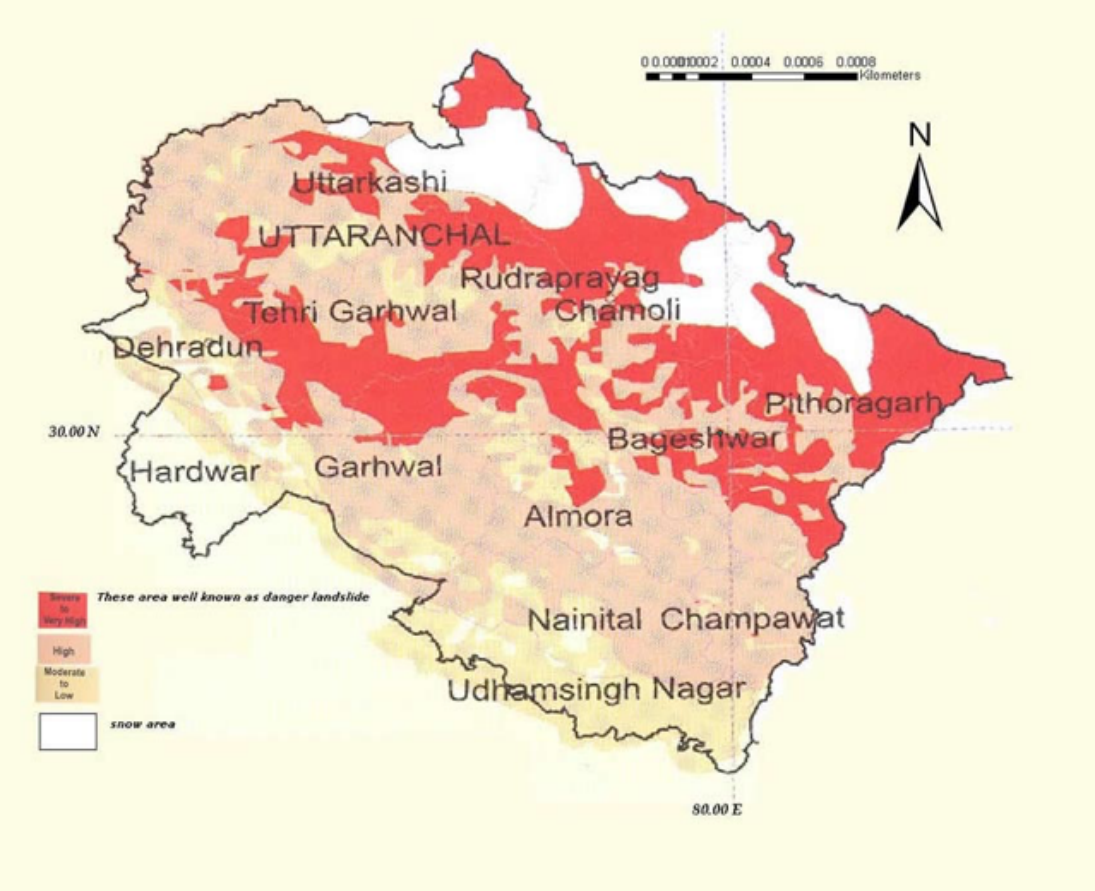


Figure 7: Landslide Hazard Zonation Map Uttarakhand
(Source: http://usdma.uk.gov.in/landslide-80.aspx)

Uttarakhand has a geographical area of 53,483 sq km; 93 percent of which is mountainous and 72 percent is under forest cover. As 27 state of the Republic of India, Uttarakhand has two divisions; Garhwal and Kumaun. The state has 13 districts and of these seven (Pauri Garhwal, Tehri Garhwal, Chamoli, Haridwar, Dehradun, Uttarkashi, Rudraprayag) are in Garhwal while the remaining six (Almora, Bageshwar, Champawat, Nainital, Udham Singh Nagar, Pithoragarh) are in Kumaun. Dehradun is the capital of the state.

Below is a brief discussion on some of the significant landslides in Uttarakhand.

2.1.1 SHER-KA-DANDA

2.1.1.1 Introduction

The landslides of 1867 and 1880, were both initiated on the Sher ka Danda hill. The landslide of 1880 occurred on the hill slope to the east of the 1867 slide-in which the old Victoria Hotel was destroyed. It was reported that the 1880 landslide took place following heavy rainfall for 3 - 4 days and an earthquake. Large portions of the northeast range including a number of buildings were swept away in a matter of a few minutes and the landslide debris covered the slopes as well as filled a part of the lake. The 1880 slide was particularly devastating; landslide cracks occurred in the vicinity of Old Government House (at Snow View).

2.1.1.2 Impact

This mass movement took the toll of 151 persons including 43 Europeans and Eurasians

The mass movement started in the morning hours of Saturday, 18 September 1880 amid heavy rainfall that had started on Thursday, the 16 and continued till Sunday, the 20. As much as 838 mm of rain was reportedly received on 17 and 18 September of which 635 mm was received in the 40 hours preceding the evening of 19 September. It is reported that the entire hill slope behaved like a semi-fluid material and buried everything that came in its way, including the temple of Naini Devi on the lakeside Figures 8 & 9. A rumbling noise, similar to that caused by the falling of a huge mass of earth, was reported to have been heard by many in the station; and those with the opportunity of looking towards the direction of the crash could reportedly see only the vast cloud of dust rising from around the site of the landslip. A large portion of the hill behind the hotel, from the Upper Mall, had thus disunited and descended with great velocity and violence. This completely buried the hotel and dashed together into an unrecognizable heap. The catastrophe was reported to occur for a few seconds only; so escape on the part of anyone, who came in the course of the avalanche was practically impossible (Atkinson, 1882). A portion of the lake was also covered by the landslip debris and while directing operations at the east end of the lake Sir Henry Ramsay was reportedly overtaken by a great wave generated by the debris swept into the lake (Atkinson, 1882). Before the landslip a small recreational ground existed near the northern end of the lake but after the landslip space was available for the development of the Flats. Immediately after the landslip, jets of water reportedly poured from reservoirs within the hill on the newly made face and for some time, maintained a direction and volume that reflected the large quantity and force of these factors in the landslip (Atkinson, 1882). The slide caused large cracks, some of which opened up and became more easily traceable, e.g., one emerging from Mayo Hotel (now Grand Hotel) to St. Loo Cottage and across Government House (at Snow View). Another line further east split into a rock on the summit of the little ridge above Fair light; a third line proceeded from the Club to the end of the Cheena ridge by the road west of Fairlight (Atkinson, 1882).



Figure 8: Photograph of 1875 of the Sher ka Danda hill. The grove by the lakeside below the Sher ka Danda hill is the site of the erstwhile temple of Naini Devi (Source: DMMC 2011)



Figure 9: Photograph of Sher ka Danda hill after the landslide of 1880. Houses on the hill slope along with the temple of Naini Devi have been overwhelmed by the landslide debris (Source: DMMC 2011)

2.1.1.3 Actions taken

After the landslide, further erection of buildings, quarrying and digging of terraces or platforms were prohibited on the hill slopes. Steep slopes were turfed and planted with trees and grass. Cutting and grazing were also absolutely banned.

- The catastrophe resulted in the construction of drains, 79 km in length, to safely drain off the water from the vulnerable slopes. To prevent further disasters, building bye-laws were made stricter.
- 6 miles of masonry drains and 3 miles of drains to help drain roads and the interior of hills were constructed to save the town from future deluges.
- The sluice gates towards the eastern (open) side of the town were constructed which were opened manually whenever rains caused lake levels to rise to discharge excess water.
- Catch walls were built in the upper toe region of the hills around Nainital.

2.1.1.4 Recommendations

Listed below are some of the mitigation measures implemented on the Ramsay Committee's recommendations that were constituted 4 days after the slide on September 22, 1880 and submitted its report on October 11,1880.

a. Construction of stormwater drains on all the slopes around the lake.

b. Restriction on anthropogenic activities on vulnerable slopes.

c. Measures for restricting groundwater infiltration, and

d. Regular maintenance and upkeep of the structures created.

“Nainital has witnessed landslides in 1867, 1880, 1893, 1898, 1924, 1989 and 1998.

2.1.1.5 Lessons Learnt

After the 1880 tragedy, Britishers had developed a 79 km drain network on the hill slopes around Nainital and divided Nainital into safe and prohibited zones for construction. But the lessons of the past were either forgotten or ignored by the time the 1970s came around for construction to resume on the Naina Hill as Nainital saw a boom in tourism and the local population increased from 25,000 in 1961 to over 50,000 on a single day (plus a floating population of 1 lakh). In 1930 a ban was imposed on construction on the Snow View and Naina Hills, which was extended in 1953. After 1980 and especially since 1986, construction activity has grown at a maddening pace, with even multi-storeyed hotels springing up. All norms have been either defied or circumvented. Officially, **no building should exceed 7.5 m and/or 2 stories whichever is less but the Greater Nainital Development Authority (GNDA) has allowed construction up to 35 feet**. In 1950, there were only two bungalows on Naina Hill, now there are at least 500 buildings.

The British time drainage system built to stabilize the slopes lie choked with the debris of garbage and concrete, dumped by mindless house and road builders.

i. The rainwater and household discharge result in weakening of the slope. Therefore, the proper channelization, planning and design of surface drainage networks by strengthening the existing drainage network in the catchment area should be undertaken as one of the mitigation steps.

ii. Sluice gates were converted into an automatic exit system working through pipes that would let out three inches of water. But, the system failed the town miserably whenever cloudbursts happened.

iii. Crazed by dreams of luring more tourists and larger car/bus parks, the administration chose to replace them with pipes and cemented the area to extend the Bus Adda.

iv. The Mall road area was overbuilt despite cautionary notes from experts.

v. The catchment area for Naini lake, known as Sookhatal made of dolomite and limestone, collects 40 percent of the subsurface water. Of late, that has been surrendered to builders who have cemented most of it to build hotels and resorts. As a result, the lake water keeps diminishing alarmingly.

vi. The initiation zone at the crown (top) of the mountain side be treated with soil nailing technique, a feasible and cost-effective solution.

vii. The toe (base) of the mountainside be treated with the construction of retaining walls with adequate provision of weep holes.

viii. The inclined perforated drainage pipes should be installed in between nails to drain out the seepage water from the slope.

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2.1.2 KALIASAUR LANDSLIDE

2.2.1.1 Introduction

Sirobagar, also called Kaliasaur Landslide, developed in the year 1920 at kilometer-147 on National Highway – 58 (earlier named as State Highway - 45) at latitude 300 14’ 30” N and longitude 780 53’ 57” in the Garhwal region of western Himalaya. The landslide, aging more than eight decades (1920- 2012), is a nightmare on the Hardwar-Badrinath road in the Garhwal Himalaya. Located on a sharp bend on the left bank of river Alaknanda, it has emerged as a multi-tier repetitive major landslide, retrogressive in nature. The periodic activation of this slide has changed the topography of the area to the extent that it always looks like a young slide. After its first reporting in 1920, it got

reactivated in 1952, 1963, 1964, 1965; thereafter it developed into a major landslide in 1969, 1970, 1971, 1972, 1985, 1987, 2011. In 2013, it was triggered by Uttarakhand flash floods.

2.2.1.2 Impact

After a series of landslides from 1920 to 1965, this developed into a major landslide in 1969 when it blocked nearly three-fourths width of the river (Figure 8). Also, a 300 m stretch of the road was dislocated both vertically and horizontally by about 2.5 to 3.0 m; the damage to road structure was indeed severe. The slide reportedly remained active for four days at a stretch. Thereafter, during 1970, 1971 and 1972, there was moderate to heavy landslide activity. Every time the communication system was disrupted the hill side had to be cut to accommodate rows. In September 1984, the landslide became violent following heavy rainfall; it damaged the road considerably and pushed its rear scar retrogressively. Its reoccurrence in August 1986 was equally severe. The total area of the slide, above and below the road level taken together, measured 86,000 m^2 at that time. Another most recent devastating event of its activation has been during July-September 2010 when a huge amount of material discharged from the slide completely covered the highway for a 95-meter length (Figure 9). The highway remained blocked for 45 days at a stretch and also intermittently for five months. As the highway links this part and holiest pilgrimage hubs of this area namely Badrinath, Kedarnath, Gangotri and Yamnotri with the rest of the country, millions of tourists from all over the world visit each year (May-November). The Highway was blocked at this point almost every year since 1984 for few hours to several days depending upon the magnitude of the slide. During the 2010 landslide, two people lost their lives and a few have been injured, also two vehicles were crushed under the rubble. There was confusion and panic amongst the people about their journey. Millions waited for the restoration of traffic for tens of days before deciding to follow some other alternatives. During such an emergency two alternative routes, both risky and economically disadvantageous, became people's choice.



Figure 10: Kaliasaur Landslide on Hardwar-Badrinath (Source: https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=1438 & context=icchge)



Figure 11: Metamorphosis of Kaliasaur Landslide Year by Year (Source: Kumar et al. 2013)

2.2.1.3 Actions taken

The landslide was monitored for its surface and crustal movement behavior before the on set of the monsoon in 1986 (Mehrotra and Bhandari,1988).

After detailed investigation, the following measures were recommended:

1. Grading of the slope uphill of the road.
2. All tension cracks and fissures in the rocks are to be sealed.
3. Timber piling for stitching of the slope.
4. Construction of anchored drum diaphragm retaining wall along the road to control the slide mass overlooking the road.
5. Construction of anchored stone masonry wall towards another side of the road to check the under-cutting of the road due to paleo channels.

A simple method and low-cost technology for the construction of retaining walls to stabilize slopes have been developed by Bhandari (1987), which promotes extensive use of slope waste and landslide debris. The drum anchored diaphragm walling system consists of empty bitumen drums interconnected vertically (Figure-12) and laterally, filled up with wasteful debris to achieve the gravitational effect and suitably anchored at the slope foundation as well as on to the slope retained. The system of retaining walls makes use of empty bitumen drums to serve as containers. This technology was earlier implemented at Kaliasaur landslide on Rishikesh - Badrinath highway as mentioned by Bhandari (1987), IS 14680:1999 Landslide control - Guidelines, State of the Art Report: Landslide Correction Techniques SOA (1995).



Figure-12: Drum Anchored Diaphragm Wall (Source: Bhandari 1987)

2.2.1.4 Recommendations

Since at this location the main problem is of rock and debris fall of the fractured rock and overburden material, it was thought to prevent the failing mass so that it does not come on the highway and also doesn't damage the slope. Therefore, the steep face, crest, which is vulnerable to sudden detachment of rocks, is required to be treated to prevent falling of dislodged rock.

1. It is suggested to cover the slope with a steel rope net of aperture size 300mm x 300mm to stabilize the steep crest part.
2. This kind of stabilization is not intended to avoid the movement of blocks but will control rocks/debris from falling/bouncing/rolling on the surface of the slope downhill and avoid damaging highway.
3. This will help in uninterrupted maintenance of the highway and minimize the risk to the traveling public and property (CRRI Report 2012).

2.2.1.5 Lessons Learnt

1. Traditional investigation and remediation works may not be able to control complex chronic landslides.
2. Less effective and palliative control measures executed intermittently for several years to suit budgetary allocations could not prove as effective as the total corrective works executed in a single working season.
3. The thresholds of movements, movement rates, piezometric pressures, ground subsidences and heaves etc. need to be fixed in relation to the mode of failure and elements at risk.
4. A clear understanding of the dynamic interaction between human activities and slope mechanics is essential for reliable forecasting. It is not enough to predict when and where a landslide will occur in a real sense. The forecast must include the reach, spread, or runout of the slide and its damage potential. Without such a consideration, it would not be possible to save human lives and property.

5. The vulnerable situation can alleviate by the providing a proper drainage system for the retaining wall as well as suitable dewatering provision along with the landslide.
6. Greater need to formulate landslide management strategy to tackle such historic landslides like Kaliasaur.

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2.1.3 THE GREAT ALAKNANDA TRAGEDY

2.1.3.1 Introduction

On July 22, 1970 the Alaknanda valley witnessed a major flood, attributed to a cloudburst on the night of 20 July 1970 on the southern mountain front in the Alaknanda valley (between Joshimath and Chamoli). For a layman, the trinity of causative factors which unleashed Alaknanda tragedy were: (1) unusual cloud burst at Kunwari Khal, (2) consequent formation of a landslide dam in the constriction of river Patalganga simultaneously choking river Alaknanda and (3) the eventual bursting of the landslide dam generating a formidable flood wave in Alaknanda river.

The entire damage on a fateful day was attributed to the surge wave. The flood wave was attributed to the breach of the landslide at the confluence of river Patal Ganga and Alaknanda. The breach of the dam occurred due to mounting pressure in the reservoir behind it. The dam itself was formed by a huge load of sediments from the river Patal Ganga. (Figure 11 & 12). The sacraments were chiefly

due to an enormous degree of mass wasting and erosion on the slopes. And such high degrees of erosion could be directly linked with erosion due to long periods of neglect of slopes, non-engineered constructions, cutting off roads and such activities.

2.1.3.2 Impact

A brief account of the damages is given below:

1. A double tube English Bridge of span 40 m at Helang (km 261) got washed away. The Helang slide, located 13 km downstream of Joshimath, occurred on the bank of Karmansa Nala, upstream of its confluence with river Alaknanda. The riverbed at this location had already silted up to the bridge deck level.
2. The Langsi bridge at km 254 was destroyed. A kilometer downstream, the Belakuchi slide (km 253) synergized with the flood wave in the Alaknanda valley unleashing what came to be known as the Belakuchi tragedy of July 1970. It is believed to have been initiated by the twin effect of severe slope toe erosion and movement along the foliation plane of a thick talc schist band. As a result, the steel girder bridge got washed away. The Belakuchi Bazaar too was wiped out and so was the bus terminal. As many as 3131 human lives were lost. It did not even spare the GREF camp located at an elevation of 45.7 rn from the riverbed. The other losses included 245 heavy vehicles comprising buses, taxis and an army vehicle. It was here, between km 253 and km 251, that the road completely disappeared and so were 15 culverts and 2 causeways.
3. The Siol landslide (km 249) occupied an area that measured 300m x 180m. The area at this location settled between 5m and 15m.
4. Pakhi landslide occurred at km 247; a fault zone may have been partly responsible for this side.
5. The road between Pipal Koti (km 245) and Birahl (km 235) underwent widespread subsidence as the trail of devastation traveled further downstream.
6. A major blockage occurred upstream of the confluence of Birahi Ganga with river Alaknanda. In Birhai gorge resulted in an afflux of l0m and 12m. A three km stretch of the road got wiped out throwing a huge load of debris into the river. Nearly 500 m of the left bank and the abetment of the Girder Bridge at Birahi got washed away.
7. Flood wave surged further down towards Chamoli (km 227), a 300 m long stretch of the road was completely washed out.
8. Downstream of Chamoli right up to Srinagar, a total of 350 m of road length got breached. Also more than a km of retaining and breast walls were lost and more than 2 km of drains were impaired and as many as 40 culverts and 5 causeways were lost. After the floodwater receded, the road at Srinagar [km 131] was found to be under 1 to 2 m of silt.
9. The July 1970 Nandprayag landslide around km 216 measured 200m x 160m. The slide was responsible for repeated blockades.
10. The river Alaknanda severely eroded its left bank at Srinagar and the situation progressively became bad to worse, year after year. In most places, the road formation was lost.

On 20 July 1970 within a short span of 45 minutes, there occurred a spate of landslides, the most important among them were Helang, Belakuchi, Tangai, Sial, Pakhi, Birahi and Nanadprayag.

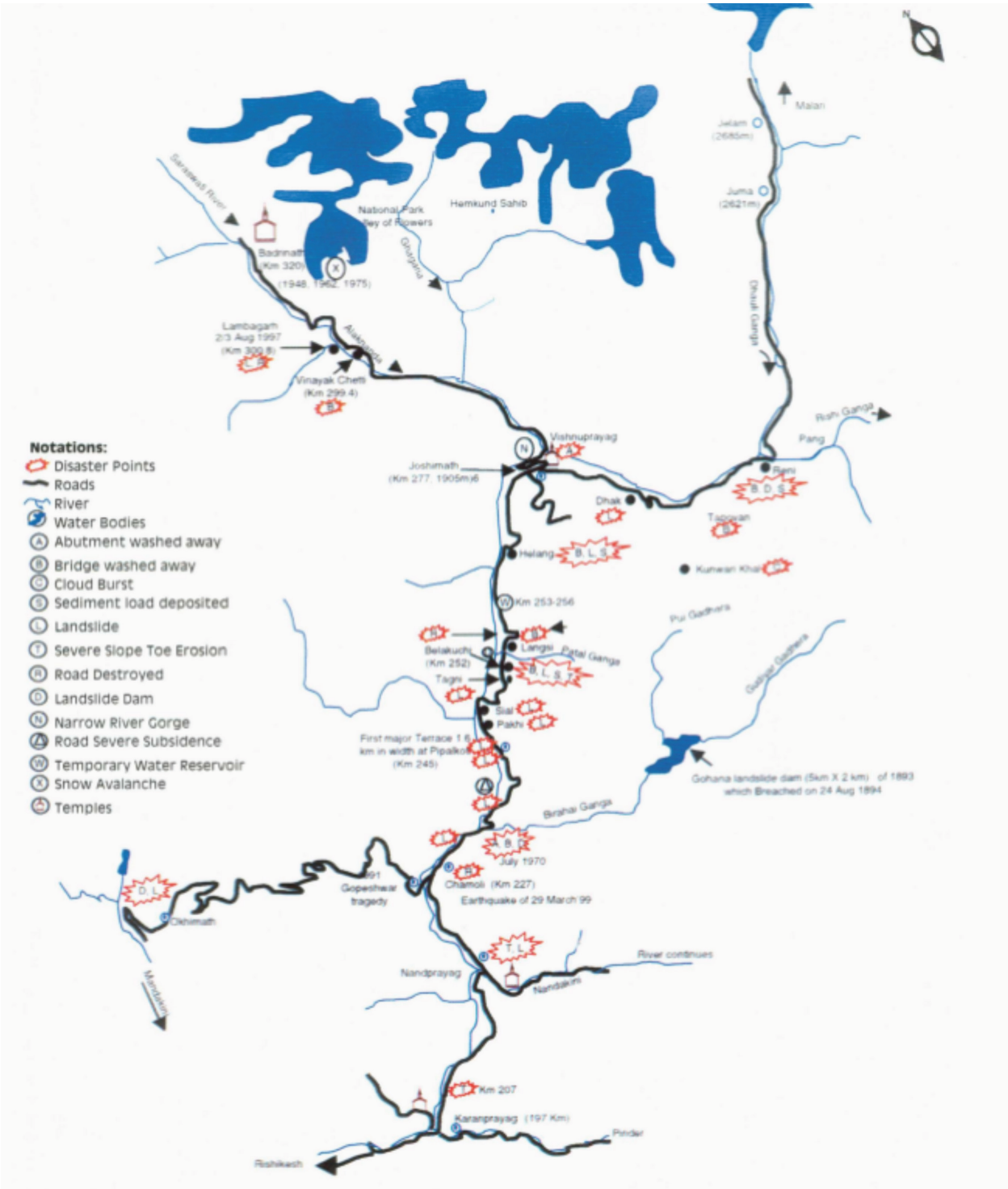


Figure-13: Trail of Devastation unleashed by the landslides and the Alaknanda Floods of July 1970 (Source: Bhandari 1999) http://cidbimena.desastres.hn/docum/crid/Jun-Jul2004/pdf/eng/doc15221/doc15221-contenido.pdf

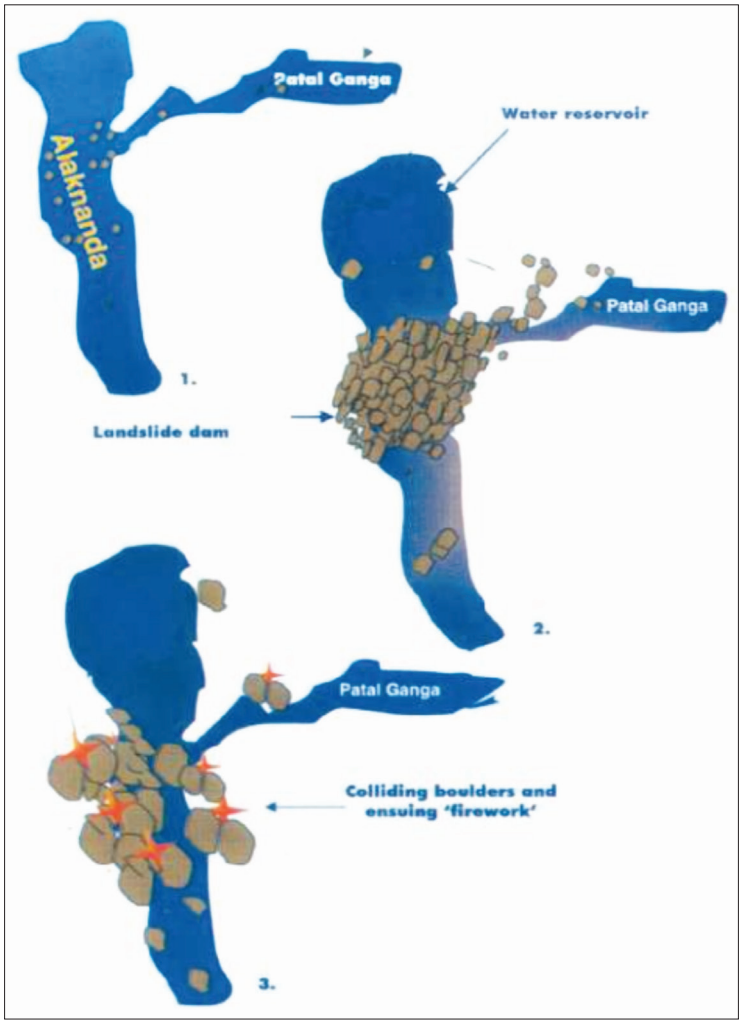


Figure 14: Alaknanda tragedy triggered by the bursting of the landslide dam
(Source :http://cidbimena.desastres.hn/docum/crid/Jun-Jul2004/pdf/eng/doc15221/doc15221-contenido.pdf)

2.1.3.3 Actions taken

1. Due to the alertness of a police constable about 400 pilgrims on way to Badrinath were guided to run uphill, thus saving their lives.
2. After the disaster, Indian Armed Forces took the initiative to provide rescue, rehabilitation and monetary help to the victims.
3. The 1970 Alaknanda flood was responsible for raising the ecological consciousness of the people. This resulted in the birth of the world-famous Chipko movement in 1973.

2.1.3.4 Recommendations

1. Available technology needs to be used effectively.
2. Emphasis to be given to simulation and early warning; also, communication protocols and strategies to be revisited.

3. Data/information to be converted into user-friendly formats for administrators and the common man. Action research may be given priority.
4. SOPs and plans to be put in place.
5. Hotspots need to be identified and interventions need prioritization.
6. Better practices (Engineering and Land-use) while redeveloping.
7. Fragile environmental sensitivity of the ecosystem to be kept in mind while carrying out development work.
8. NDRF to be strengthened in terms of both human as well as material resources. SDRF to be set up and made functional.

2.1.3.5 Lessons Learnt

1. Blocking of a river or its tributary due to landslides can lead to the formation of temporary lakes and bursting of such transient lakes may bring huge devastation on the downstream side.
2. Apart from the "wrath of nature", faulty policy-making and corruption is also responsible for the loss of precious lives and livelihood.
3. We must seek to achieve growth and prosperity even with limited resources and by following sturdy sustainable methods.
4. Drastic changes in the river water levels must be recored carefully and the information to district and state authorities.

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2.1.4 BHETI-PAUNDAR LANDSLIDE

2.1.4.1 Introduction

On 18th-19th August, 1998 Bheti slide took place. There was a thunderous sound of rolling boulders and there also occurred a huge duststorm that covered a radius of more than two kilometers. Bheti's slide shows distinct structural control. Rainwater entering through the fracture zones enhanced the pore water pressure and the whole mass moved downslope along a pre-existing weak plane. The movement was so fast that the downward moving mass acquired enough momentum to move upslope

(~200 m vertically) on the opposite bank where it destroyed the habitations and caused immense loss of human lives and property.

2.1.4.2 Impact

The landslide blocked the course of Madhyamaheshwar river for about 24 hours. There was panic downstream up to Haridwar, while people at Srinagar, having witnessed the fury of rising waters in the past, were particularly cautious. The incidence of the 1970 tragedy was fresh in the memory of many residents. Bheti landslide pushed the death toll to 107 in the 29 villages of Okhimath tehsil. This also caused heavy loss of property and changed the geomorphic setup of the surrounding area. The agricultural lands and habitations were replaced with heaps of boulders and debris and the two streams that used to meet Madhyamaheshwar river near Paundar lost their courses amid the debris. Few days before its occurrence, local inhabitants had reportedly observed a wide crack over the Bheti slide area. Water percolating through it and encompassing weak zone along with pre-existing weak planes must have facilitated the downward flow of rockmass. An under-construction road activity in the vicinity, employing use of explosives, must have caused widening of the fissures and eventually triggered the movement. Also, toe erosion by Madhyamaheshwar river must be one of the prime reasons for destabilization of hill slope, eventually initiating/triggering movement along the pre-existing weak planes.



Figure 15: View of the Bheti landslide of 18-19 August 1998 that blocked the course of the Madhyamaheshwar river for 24 hours (Source: Rautela and Thakur, 1999)

2.1.4.3 Actions Taken

1. Even before assessing the magnitude of the threat, the overenthusiastic administration added to the panic of the people by giving a call for evacuation
2. Incessant rains caused hurdles in rescue and relief work. The entire operation became all the more difficult due to wide sway of the slides and lack of desired coordination among various agencies.

2.1.4.4 Recommendations

1. Compulsion of bringing more land under cultivation lead to increasing the height of embanking walls of the terraces, which stayed in perpetual destabilized state. Scientific studies should be undertaken for modifying the existing unstable terraces and also for designing new ones.
2. Portions of river embankment, which have debris slopes should be covered with local varieties of stabilizing plants.
3. There should be active involvement of village panchayat and local community in following implementation measures for preventing the occurrence of landslides, and if the event does take place, in adopting remedial measures.

2.1.4.5 Lessons Learnt

1. A comprehensive strategy for relief and rescue also needs to be prepared to keep in view the fragility of the region that often destroys the conventional infrastructure at the time of the exigency and the bureaucracy should be well versed with the relief and rescue operations that they have to undertake.
2. Landslide hazard zonation needs to be undertaken in a systematic manner using the state of the art technology to demarcate high-risk zones.
3. The administration in these zones should be specially trained and should be engaged in regular drills of rescue operations to ensure that there is no mismanagement when the tragedy occurs.
4. The opinion of the scientific community, as also the traditional beliefs and practices of the locals need to be given due weightage while making various developmental policies for the high hazard-prone areas.
5. There must be awareness and capacity-building programmes for the local community by the local administration in disseminating the knowledge on the landslide triggering factors and the knowledge of early warning signals.

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2.1.5 THE KILLER MALPA ROCK AVALANCHE

2.1.5.1 Introduction

During the 1998 monsoon, a massive mass movement occurred on 18 August 1998 at about 3:00 am near Malpa Village in Kumaon Region. According to the district administration, the slide was one of the worst of its kind. A precursor to the main rockfall event in the Malpa Gad (2280 m) is said to have happened on the morning of 16 August 1998 when three mules got killed. The rockfall blocked the Malpa Gad and formed an artificial lake, which bursted on the intervening night of 17-18 and released a huge amount of water together with boulders and debris. The tragedy occurred when the Malpa rivulet, overflowing due to incessant rain, shifted its course and washed away the campsite. As the victims were asleep when the water came gushing in, they did not get a chance to move to safer places.



Figure-16: An aerial view of Dharchula

(Source : https://www.tribuneindia.com/1998/98aug24/head3.htm)

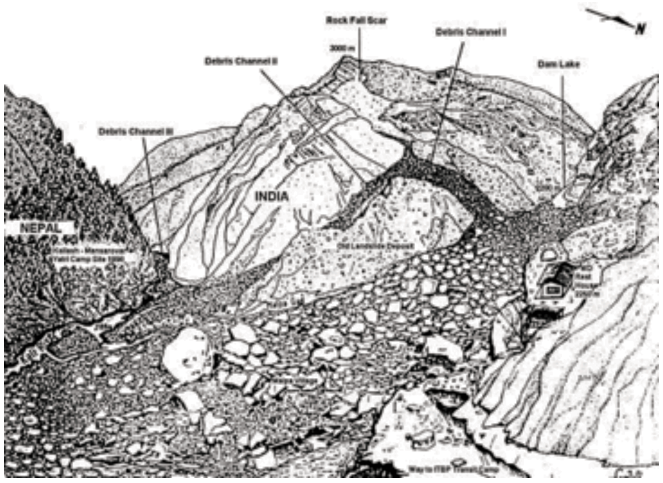


Figure-17: Diagrammatic sketch of Malpa landslide zone showing the morphology of the slide (Source: S.K. Paul et al.2000)

2.1.5.2 Impact

This massive tragedy took a toll of 221 people, 60 of them pilgrims enroute to Kailash-Mansarovar in Tibet. The first video footage of the devastation caused by landslides at Malpa in Pithoragarh district of Uttarakhand depicted badly mutilated bodies, including some with missing limbs, huge mounds of debris and rain-soaked hills. A 30-minute video capsule made by the Indo-Tibetan Border Police (ITBP) on the search and rescue operations showed "stomach-churning" visuals of decomposing bodies carried from the practically inaccessible mishap site to Dharchula, 30 km from Malpa. Weather had become the main obstacle in the search and rescue operations. Malpa is situated in a narrow valley about 60 km from Dharchula at an altitude of 2275 m. The rescue operations were also hampered due to the tough terrain of the site.

In terms of economic loss, the camp and residences of KMVN, the material and the minimum permitted amount of 500 dollars for payment to the Chinese agency of the pilgrims was destroyed in the debris. Around fifty mules, each costing ₹ 10-12 Thousand were dead, which had been the only source of livelihood for most of their owners. They would earn about ₹ 200-250 per day during the pilgrimage period only and live on this earnings for the whole year. The local residents of that area, who lost their lives, were mostly young and many were the only earning members of their family.



Figure-18: Body of a victim of the Malpa landslide being taken out of a helicopter at Dharchula

(Source : PTI (The Tribune, August 24, 1998)
https://www.tribuneindia.com/1998/98aug24/head3.htm

2.1.5.3 Actions Taken

1. Three rescue teams from the Army, comprising nearly 50 jawans, reached the Malpa village in Pithoragarh district after the incident but they could not commence the rescue operations due to bad weather at the accident area and large heaps of debris, said to be as high as 15 m.
2. During the day IAF helicopters made a couple of attempts to reach Malpa village, but the hostile weather conditions prevented the rescue operations.
3. The defence forces made all preparations to carry out relief operations.
4. The government gave blanket permission for carrying out medical and relief operations.

5. IAF's Central and the Western Command were put on alert and both of them sent aircrafts/ helicopters loaded with relief supplies and medical aid. All helipads in the region were also put on alert.
6. Big helicopters, namely Cheeta, MI-18, MI-17 and Chetak, were kept in readiness. As and when they get the nod, they would fly and complete their mission, provided the weather conditions permitted.
7. The medical and para-medical staff in the region was alerted for providing immediate attention to the injured.
8. The Army personnel were asked to reach near Mandakini river as the area was blocked by boulders. They were instructed to carry out strategic blasts for clearing the course of the canal and repairing breaches in the canal course.
9. Prime Minister Atal Behari Vajpayee sanctioned ₹ 12.5 Million from the Prime Minister's National Relief Fund for disbursement among families of 250 persons feared dead in the landslides.
10. The men from Army's Rajput Regiment had to use ropeways to reach the spot where the Madhyamaheshwar river had changed its course after the landslides, which resulted in the creation of a 3 km long and 800 m wide lake.
11. The Chief Minister, Mr. Kalyan Singh, had announced an immediate relief of ₹ 50,000 each to the families of those killed. Further, if the deceased happened to be the sole earning member of the family, the amount was raised to ₹ One Lakh.
12. Besides, a sum of ₹ 25,000 was immediately paid to all persons whose houses had collapsed.
13. Employment was provided to people in these areas under the S.Y.S. scheme and the deserving people were provided houses under the Indira Avas Yojna.

2.1.5.4 Recommendations

The devastating landslides of the 1998 monsoon call for a comprehensive landslide hazard zonation and risk assessment program in the region so that the human suffering associated with these catastrophic events can be minimized.

2.1.5.5 Lessons Learnt

1. Natural disasters cannot be avoided but all possible attempts to mitigate their effects should be made in a timely manner.
2. Population pressure has perhaps compelled masses to undertake cultivation on slopes that are traditionally considered unfit for such an activity.
3. The natural compulsion of bringing more land under cultivation forces increase in the height of the embanking walls of the terraces. This in turn adds to the instability of these terraces. Water impounded in these soils due to prolonged rains further added to the instability of these slopes.
4. The landslide record shows that most of the slides take place during the rainy season. It, therefore, becomes imperative to check-in for anomalies in the rainfall record.
5. The strategy of development in the hilly regions thus needs reorientation and water management needs to be given top priority.

6. Participation of the masses and revival of the traditional practice of maintaining jungle guls needs promotion for it is the most cost-effective and time-tested mitigative measure.
7. Microseismic studies are warranted in the region.
8. Interestingly, all the dogs of Malpa village rushed to safer locations and reportedly none suffered casualties. These animals are known to sense earthquakes well in advance. If they can really sense the slides their facilities can be used for the common good of humanity.

2.1.5.6 References

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2.1.6 PHATA-BYUNG LANDSLIDE

2.1.6.1 Introduction

In the late night of 16 July 2001 (00.45 am to 3.00 am) cloud burst occurred in the Phata Byung area of Rudraprayag District in the Garhwal Himalaya, India. The heavy precipitation induced (or triggered) more than 200 landslides and adversely affected the slopes of Byung and Gabni sub-watersheds of Mandakini Valley, resulting in massive debris avalanches and other forms of slope failure, evidenced by a large number of deep and shallow scars on the slopes on both sides of the valley.



Figure 19 Phata Landslide of 16 July 2001 (Source: Piyoosh Rautela 2015)

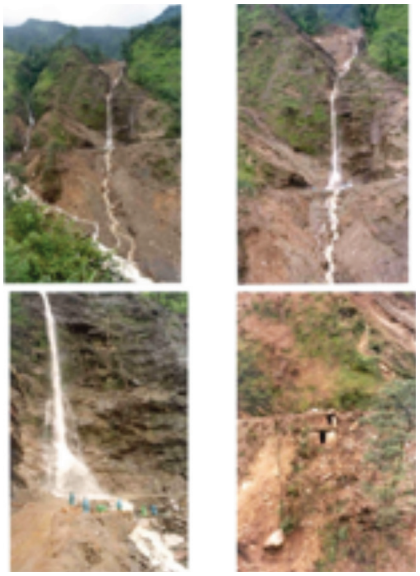


Figure-20: Byung Gad Landslide of 16 July 2001 (Source: Piyoosh Rautela 2015)

2.1.6.2 Impact

The losses assessed by Naithani 2002 and local government agencies were: 27 human lives, 64 heads of cattle, 22 horses and 43 hectares of agricultural land. In all, almost 15 villages including Dhani, Jamu, Saimkurali, Khat, Khariya, Rail, Ravigaon, Byung, Phata, Tarsali, Dhani, Saimkurali, Khariya and Tarsali weer severely affected and 3924 people staying there faced the brunt. The road along the Kedarnath—Guptkashi segment suffered maximum damage and the major disaster occurred at Phata Market and along the Byung stream (Table-3).

TABLE 3: SURVEY DETAILS OF THE PHATA BYUNG TRAGEDY ON 16 JULY 2001 (NAITHANI ET AL. 2002)

Total number of villages affected — 15
Total population affected — 3924 Men
Died — 27
Injured — 11
Livestock
Died — 64
Injured — 4
Houses
Completely damaged — 22 Partially damaged — 55
Agricultural land affected — 43.115 ha
Motor road damaged (major) — 13 km (Davidhar to Barasu)
Footpath — 42 km (approx.)
Estimated loss because of motor road and footpath — Rs 2.75 crore
Bridges

Small and severely damaged – 5
Completely washed-out – 2 (one arc and one steel)
Grinder (grain) – 11
Micro hydropower plant completely washed out – 1 (capacity 10 kW)
Government buildings
Completely damaged – 36 Partially damaged – 58

2.1.6.3 Actions Taken

1. State Government gave a quick response to the situation. An Emergency Control Room has been set up at Guptkashi having contact Nos. 0136-407241, 0136-467221.
2. Arrangements to airdrop foodstuff and supply other essential commodities and provision of temporary shelters like tents, tarpaulins for villages were made.
3. Major damages to the electricity and water supply systems in the affected area.
4. The detailed memorandum was sent by the State Govt. after assessment.

2.1.6.4 Recommendations

Naithani et al. 2002 and Chaudhary et al. 2008, recommended the following:

(i) Many villages in this area like Dhani, Jamu, Semkurala and Talla Khumera may be washed away in the next rainfall. Hence, people, livestock etc. need to be shifted to safer places immediately.

(ii) There is an immediate need for the identification of areas that are relatively more vulnerable to landslides and mass movements.

(iii) Future construction will only be allowed after detailed studies on the local stability of terraces and the evaluation of the geotechnical parameters of the allowable bearing pressure of the slope material. We must not formulate any development activity plan without an understanding of the tectonic setup of the region.

(iv) Building construction practices over solifluction lobes, landslides debris and MCT escarpment in this region should be stopped.

(v) Public awareness programmes to train people to cope with this problem and situation, must be initiated.

(vi) After this event in 2001 the GREF constructed a small bridge along the road over the Dhom Gad and presently all the discharge of Dhom Gad is comfortably flowing beneath the bridge and reaching the Byung Gad. Still, two small bridges are required to replace the causeway for Dhom-1 and Syul where a new subsidence/sinking zone is initiated along the road between Dhom and Syul.

(vii) GREF although constructed some RCC structures along the right bank of Byung river, which are protecting the toe erosion but the appropriate structure was not constructed at suitable locations and some of them have tilted and fallen. There is an immediate need to construct some gabion structures to protect these RCC structures, along the lateral sides of the drainages to protect lateral erosion / scouring below the road.

(viii) The proper surface and subsurface drainage treatment and proper RCC structure along with gabion walls may protect against further sinking in this zone.

2.1.6.5 Lessons Learnt

1. The area lies in the seismic zone V and also falls in the zone of very high precipitation. The continuous threat posed by the landslide must be evaluated, particularly during the rainy season.
2. Construction of houses over weak rockmasses must be restricted
3. Adequate strengthening and grouting measures must be followed before doing construction over weak slope masses.
4. Quick response teams should be kept ready during the rainy season to help people during disasters.

2.1.6.6 References

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2.1.7 VARUNAVAT PARVAT LANDSLIDE

2.1.7.1 Introduction

On 23 September 2003, a massive landslide occurred in the Varunavat hill and endangered the Uttarkashi Township. The Varunavat Parvat is situated on the right bank of the Bhagirathi River. At the foot of the mountain lies the Uttarkashi Township. The event of mass movement at the Varunavat Parvat is a typical example of 'debris slide' with rockfall and rockslide in the middle of the slope. The slide occurred in two distinct phases. The first involved rotational sliding of about 20-25 m along a prominent joint plane, while the second caused the toppling of a large block that disintegrated and initiated a rockfall and rockslide in the middle portion of the slope. The rock debris from the top of Varunavat Parvat started falling on the night of 23 September 2003 and continued for the next 15 days. The crown of the landslide was located 1675 m above mean sea level (amsl) and about 700 m above the Rishikesh-Gangotri National Highway. The area is sparsely vegetated with pine trees, occupying about 30% of the area. Figure 21-23 illustrates the Varunavat parvat landslide.

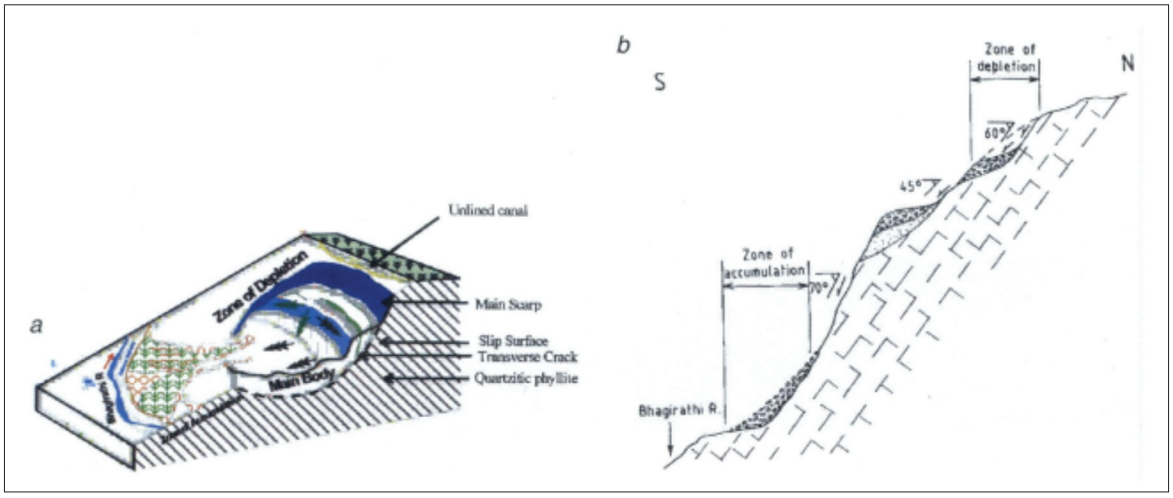


Figure-21: (a) Schematic block diagram of Varunavat Parvat landslide, (b) Cross-section of Varunavat Parvat slide along the Ramlila Ground slide track as of 10 October 2003 (not to scale) (Source: Gupta and Bist 2004)



(a)



Figure-22: (a) Pre-landslide scenario and (b) post-landslide scenario of the Varunavat hill (Source: Sarkar et al. 2011)

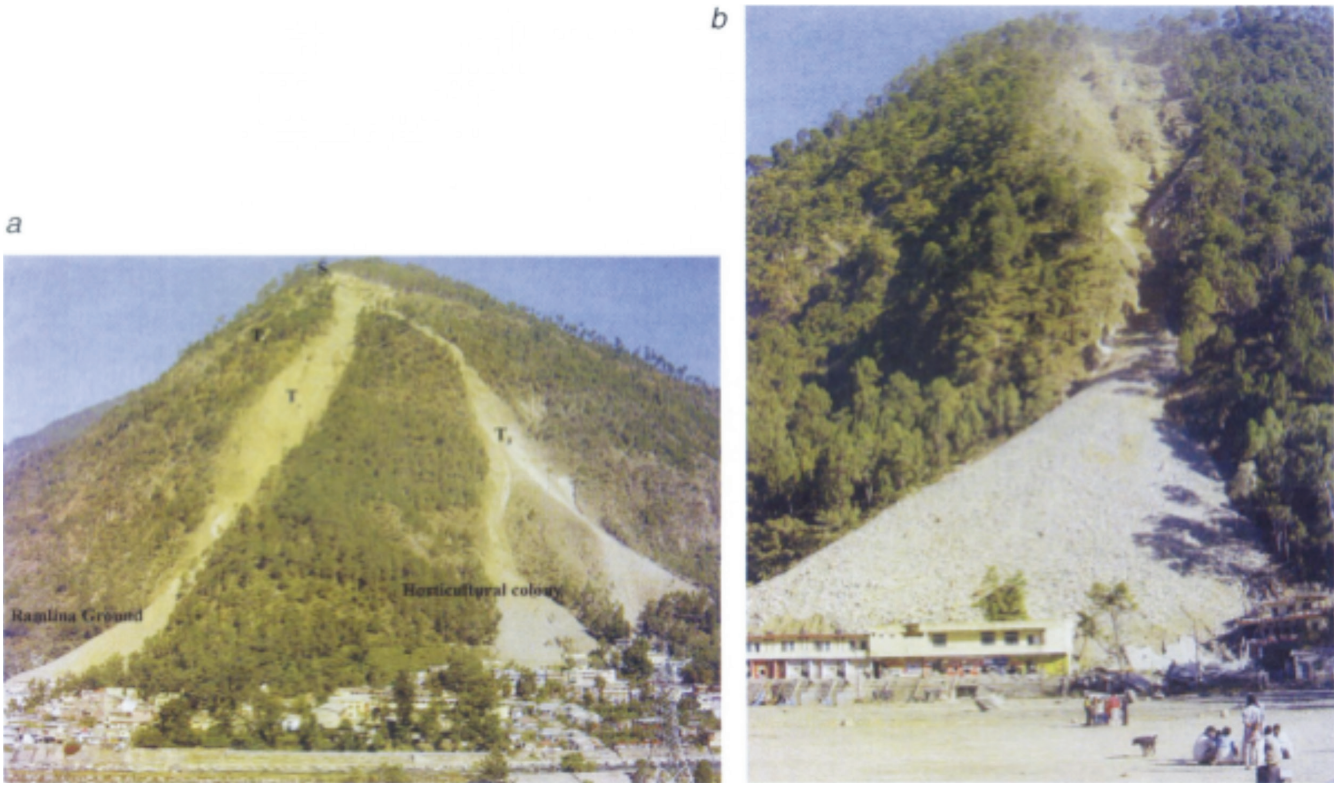


**Figure 23:.(a) Panoramic view of Varunavat Parvat slide.
Si is the location of the main Varunavat Parvat landslide.
T1, T2 and T3 are the three different transportation zones.
Ramlila ground and Horticultural Colony
accumulation zones are also visible,**

**(b) View of Ramlila Ground accumulation zone.
An estimated volume of about 25,000-30,000 m3 debris
has been accumulated in this zone. This debris buried many residential and
commercial establishments and also caused huge damage to the infrastructure.
(Source: Gupta and Bist 2004)**

2.1.7.2 Impact

The landslide destroyed many structures, in which about 360 houses were completely or partly damaged (Figure-24). Also, hotels and tourist lodges located along the NH-108 were completely buried under the thick cover of landslide debris. Residential houses and government buildings were also affected. Nearly one kilometre road length of the National Highway remained blocked for about a month. There was also a loss of forest on the uphill slope hill owing to the movement of boulders and debris material.



Figure-24: Buildings that were later buried by debris (Source: Sarkar et al. 2011)

2.1.7.3 Actions taken

There were no casualties reported. The district administration along with scientific organizations worked together to evacuate the houses in time. This avoided a potential major disaster. The administration took prompt action and followed the recommendations of the experts (see 'Recommendations' below).

The slope was modified and shotcreting was applied with wire mesh reinforcement on the entire slope. Rock anchoring and rock bolting were implemented to strengthen the weak jointed and fractured rocks. After covering the main landslide scarp at the crown portion with a geo-grid, bio-measures were adopted to protect the slope from erosion. Special grass was planted to stabilize the slope through root reinforcement. Subsurface horizontal drains were installed at various levels to drain groundwater. Surface drainage was also constructed at various levels to drain surface runoff from the slope. At the toe, a retaining wall was constructed to provide support to the slope. Till 2011, the slide appeared to be stabilized and no activity was reported after the implementation of the above control measures. But a landslide at Varunavat Parvat on 29 August 2018 caused injury to three people and a couple of structures collapsed.

The recommendations of GSI (see 'Recommendations' below) were followed and a vehicular track was made to reach the uphill slope. The accumulated debris resting in the middle of the slope and at the road level was removed and disposed of in an adjacent valley and covered with biodegradable jute mesh to avoid erosion and debris flow. The control measures were implemented during 2008-09.

2.1.7.4 Recommendations

A reconnaissance survey of the slide area was carried out by a team of experts (formed by the Ministry of Home Affairs, Government of India) within a week after the occurrence of the slide. They recommended the following remedial measures:

(i) Sealing of cracks, slope grading, construction of retaining walls, proper drainage measures, soil reinforcement and biotechnical measures.

(ii) The GSI recommended control measures to arrest the sliding activity. These are mainly slope grading, shorting, surface drainage and rock anchoring.



Figure 25: Scenario after implementation of control measures. (a) View of the landslide from the top. (b) Bio-measures at main scarp. (c) Rock anchors, rock bolts and subsurface horizontal drain (Source: Sarkar et al., 2011)



Figure 26: View of Varunavat Parvat in 2018 (Source: https://timesofindia.indiatimes.com/city/dehradun/fifteen-years-after-major-landslide-shook-varunavat-mountain-uttarkashi-residents-fear-similar-disaster/articleshow/65627208.cms)

2.1.7.5 Lessons Learnt

1. Townships should not be built below foothills unless stability is ensured.
2. The extent of the buffer zone should be assessed by a competent geologist based on full knowledge of potential landslide type, slope morphology, debris material and its volume.
3. There is a need for large-scale landslide hazard mapping and risk evaluation that will lead to efficient landslide disaster management.
4. By following the disaster action plan; we can prevent or minimize the impact of disaster and can save precious lives and properties.
5. In the initial phase, the then Prime Minister Atal Bihari Vajpayee approved ₹ 282 Crore for the treatment of Varunavat Hill. Apart from this, crores of rupees have also been spent on the construction of roads. The treatment of the Tambakhani zone was supposed to start in 2016 but it could not be done. Now there is a stir in the Disaster Reduction and Management Department due to the incident of falling boulders. If the treatment of Tambakhani had been done earlier, the incident of boulders probably would not have happened.

2.1.7.6 References

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2.1.8 DEVPURI AREA, CHAMOLI

2.1.8.1 Introduction

The catastrophic landslides of Devpuri, 140 km from Chamoli, took place on 12 July 2007 as an aftermath of heavy precipitation. An area of about four sq km. received very heavy precipitation and caused multiple landslides in eight villages viz. Devpuri, Patal Kharak, Lati Kharak, Suri Kharak, Kutuchgair, Chindulichani, Kalu Kharak and Patharkata, all falling in Devpuri Panchyat, and of these

first six were the worst hit. The mass movement was of three types, namely debris, block and rock-cum-debris and these severely disturbed the transport network, electricity and completely damaged the water supply system.

2.1.8.2 Impact

The losses assessed by the Naithani et al. 2011 and the local governmental agencies are given below:

TABLE 4: SURVEY DETAILS OF THE DEVPURI TRAGEDY ON 12th JULY 2007 (NAITHANI ET AL. 2011)

Total number of affected villages	08		Houses	Collapsed	03
Total population	1341			Damaged	14
Area of village panchayat	191.83 ha		Cow pen	Collapsed	02
Total families	195			Damaged	13
Total Houses	195		Water tank	2	
Total agricultural land	71.942 ha		Toilet	1	
Irrigated land	0.802 ha		Play house	1	
Unirrrigated land	71.40 ha		Agricultural land	16 ha	
Total SC families	108		Motor road damaged	4 km	
No. of families affected	57		Foot-path	16 km	
Mankind	Death	8	Bridges	03	
	Injured	20			
Cattle	Death	16	Total landslides	64	
	Injured	22	Total losses	Rs 200 lakhs	

2.1.8.3 Actions Taken

1. Agriculture on the slope is the source of livelihood for this region, so there is an urgent need to find out alternate agricultural practices or for promoting non-land-based economic activities for this region.
2. Selection of proper grazing sites should be made in eco-fragile zones because grazing, many a time enhances soil erosion and compounds the landslide events.
3. Proper assessment of slope stability is required, debris should be dumped on suitable sites and adequate drainage measures are essential since water seepage causes stability problems.
4. Hillside catch water drains and culverts should be provided.
5. The exact causes of a cloudburst are unknown and even today scientists are not in a position to say regarding the recurrence of cloudburst events. The threshold value for this event is still unknown. So, there is a need for the preparation of a regional climatic-hydrological atlas, so in the future scientists can correlate the relationship between the actions of water with the landslide activity.
6. Overhanging boulders and overburden (thickness > 1 m) on the steep slopes should be removed.
7. Given the fragility of the region, Government and NGOs should work on the creation of a voluntary,

community-based preparedness system of the watch, monitoring and alert. This will not only be useful at the time of a disaster but will provide enough self-confidence (and thereby self-reliance), an essential objective of an effective rehabilitation programme.

2.1.8.4 Recommendations

Given the fragility of the region, Government and NGOs should work on the creation of a voluntary, community-based preparedness system of the watch, monitoring and alert. This will not only be useful at the time of a disaster but will provide enough self-confidence (and thereby self-reliance), which is an essential objective of an effective rehabilitation program.

2.1.8.5 Lessons Learnt

1. Developmental activities should be executed only after detailed investigations by specialized persons/agencies/institutions.

2. Within the villages, some areas are very safe, which should be highlighted in the village level disaster management plan. These should be considered for any or all future developmental activities.

3. One should avoid construction works in the areas adjoining to seasonal/perennial streams and leave sufficient edge distance for buildings, and as per the site condition, a minimum of four to five metres is essential.

4. Training programmes are essential for capacity building for this type of study and transfer of knowledge to user agencies.

2.1.8.6 References

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2.1.9 BERINAG-MUNSIYARI ROAD LANDSLIDE

2.1.9.1 Introduction

A landslide disaster occurred on 8 August 2009 near Kuity village on Berinag–Munsiyari road in Uttarakhand. The precise location of the slide area is 30°01′17.46″N (Lat) and 80°08′58.75″E (Long) lying seven km from Kuity village at an elevation of about 1600 m. The slide was triggered by cloud burst, which caused massive debris flow along the stream 'Paniyali Gad', which flows from west to east and meets Jakula River flowing from north to south and meeting the Ramganga River near Tejam.



Figure 27: Panoramic view of the landslide near Kuity village on Berinag-Munsiyari road (Source: S. Sarkar and D. P. Kanungo, 2010)

2.1.9.2 Impact

In the wee hours (at around 2.30 am) of 7 August 2009, the Banjani hill under Dafa Gram Panchayat, cracked due to cloudburst. The debris buried 38 people of Jhekala and five from Bedumhar village. The landslide wiped out a couple of villages, namely Jhakhla and Lah. The houses situated on the downhill slope below the road were completely ruined. The debris came down from the higher reaches of Paniyali Gad and after destroying the road and the villages settled on the downhill slope. The impact of debris flow was so intense that within no time, all residents of the villages were buried. 300 drains of cultivable land were destroyed and five dozen animals also lost their lives.



Figure 28: Post landslide scenario (Source: S. Sarkar and D. P. Kanungo, 2010)

2.1.9.3 Actions Taken

1. District administration officials rushed to the site immediately after the incident to carry out relief and rescue operations with the help of the personnel of the Indo-Tibetan Border Police.
2. The government had distributed ₹ 43 Lakh to the kin of the deceased at the rate of one Lakh per casualty and also talked about the resettlement of the families in danger. As many as 12 families from LA live in Jhekala. Also, four families settled in the Terai. Jhekala's 15 families live in Chachana.
3. Those injured in the incident were provided free treatment by the government.

2.1.9.4 Recommendations

1. The site needs a detailed investigation to suggest some suitable remedial measures to protect the debris and to stabilize the unstable mass above the road level.
2. A dense network of rain measuring stations should be installed particularly in the areas with history of cloudbursts. Dissemination of rain data along with landslide warnings can be transmitted to landslide-prone areas with high risk during heavy downpours.
3. The terrain is such that transported debris might settle at or near the site, thereby leading to the formation of landslide dams on the Jakula River upstream, a potential threat of flash flood down stream.

2.1.9.5 Lessons Learnt

1. The landslide event has sent a strong signal for the urgent need for landslide risk analysis.
2. Such a massive landslide hazard cannot be prevented, but the consequences could be minimized if there is proper risk estimation, planning and execution before the next event.
3. With the help of high-resolution satellite data, source zones of landslides can be identified and terrain features along with geomorphological characteristics could also be mapped.
4. Mushrooming of temporary shops and buildings close to roadsides near river tributaries could be dangerous.
5. Intense rainfall in the upper reaches might lead to debris flows and flash floods downstream.

2.1.9.6 References

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2. 15 killed in cloud burst in Uttarakhand (2009, August 9). India Today. https://www.indiatoday.in/india/story/15-killed-in-cloud-burst-in-uttarakhand-53904-2009-08-09
3. Kalika Rawal/Jeevan Danu/Amar Ujala, Pithoragarh/Nachni Updated Tue, 07 Aug 2018 https://www.amarujala.com/uttarakhand/pithoragarh/nine-years-later-not-even-filled-with-wounds-of-zachala.

2.1.10 KAPKOT LANDSLIDE

2.1.10.1 Introduction

The incidence of landslide happened on 18 August 2010 at 09:25 hrs near the school at the hill slope due to flash flood in a nullah under Sumgarh village in Kapkot tehsil of Bageshwar district, Uttarakhand on account of a flash flood, resulting from incessant rain that lashed the Kumaon region. The slide area is located on the Bageshwar - Pindari Glacier road, 45 km from Bageshwar on a hill slope at an elevation of about 1400 m, on the right bank of Sarju river.



Figure 29: Rock cum debris slide/flow at the right bank of Sarju River at Shumgarh village (Source: Kumar and Mehrotra 2011)



Figure 30: Washout of link road connecting the school and abutment of the iron bridge (Source: Kumar and Mehrotra 2011)

2.1.10.2 Impact

A massive landslide, accompanied by loud thunder, occurred in the morning at 8:30 at Sumgad village. It triggered rapid flow of large volume of rock debris, which engulfed Saraswati Shishu Mandir, and in no time the entire school turned into a big graveyard with as many as 18 children of Class I and II being buried alive and over 25 getting severely injured. As large amount of debris was poured into the Sarju river from its left bank, its discharge, containing very large sized rock fragments in debris, became so large that the link road connecting the school and abutment of an iron bridge was completely washed away.



Figure 31: School building collapsed at Sumgad village (Source: snapshot from NDTV video 2010)



Figure 32: The Sumgarh incident (Source: The Tribune, 20 August, 2010)

2.1.10.3 Actions Taken

1. Few brave local people immediately sprang into action and safely rescued six children from being buried alive, a heroic feat indeed.
2. All 12 disaster relief teams were rushed to the spot soon after the incident and the personnel of the Indo-Tibetan Border Police also pitched in their rescue effort.
3. Officials and rescue workers reached the site after walking more than 10 km. A bridge enroute had collapsed and rescue workers had to use ropes to cross over.
4. As no machinery would reach there, the process of exhuming bodies from the debris had to be carried out manually.
5. Prime Minister sanctioned an ex-gratia assistance of ₹ One Lakh each for the kin of the deceased and ₹ 50,000 each in case of seriously injured from his National Relief Fund.
6. Chief Minister announced a relief of ₹ One Lakh to the next of kin of deceased and ₹ 25,000 for those injured.
7. On account of the tragedy schools in the state were ordered to close for three days.

2.1.10.4 Recommendations

1. The quarried material be removed from the back slope of the houses and further quarrying on agricultural land be banned as that would result in ground subsidence and generation of debris as the water charged with it would damage the houses located on the downslope and falling on its way.
2. Construction of concrete slabs/deep founding wire crate retaining structures of appropriate height was recommended to prevent toe cutting/bank erosion by the Sarju river. That would protect the bank of the river as well as the village.
3. Permeable walls - To arrest the movement of rocks and soil together with dewatering of the affected area.
4. Caged Gabion wall with vegetation cover should be practiced.
5. Stabilization of landslide area by growing vegetation on that - It substantially increases the cohesiveness of subsurface material, prevents surface erosion and shallow mass failures.

2.1.10.5 Lessons Learnt

1. School safety concerns were considered important as these would reduce the hazard-induced losses in schools and increase the safety of the pupils by building the capacity of stakeholders through different activities.
2. To be effective, all the slope stability-related measures must be planned and designed carefully under the supervision of experienced geotechnical engineers/civil engineers.

3. Strengthening of disaster preparedness for effective response at all levels.
4. Educational buildings must be carefully located to avoid the impacts of landslides.
5. Building safer schools and creating disaster response plans for the school at community level.
6. Creating local DRR centers at schools or community centers and giving children important positions.
7. Integrating DRR activities with Block Resource Centre (BRC).
8. Integrating science curriculum with DRR education.
9. Conducting regular mock drills for fire safety, first aid, earthquake etc.
10. Providing training to children to strengthen their capacity for identifying hazards, reducing risks and enhancing early warning mechanisms.
11. Involving children in risk identification, mapping and monitoring disaster risks in the community or school level.
12. Children to be motivated for participating and/or leading School Safety or Community Hazard Assessments to identify specific hazards, capacities and opportunities.
13. Displaying hazard maps on school buildings or their walls.
14. Building a network of schools to share experiences and resolve challenges in collaboration with local authorities

2.1.10.6 References

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2.1.11 UKHIMATH, RUDRAPRAYAG

2.1.11.1 Introduction

Ukhimath lies in the catchment area of Mandakini River, which meets Alaknanda at Rudraprayag. On 14th September 2012, a series of debris flows and rockslides occurred at Ukhimath, located in the lap of Lesser Himalaya in Rudraprayag district. The area comprises very weak geological formations, worsened by rugged topography. The rockmass in the area got destabilized by intense rains and resulted in massive devastation. A total of 505 landslides were recorded by Islam, et al. (2014). The incessant rains that had started on 13 September continued for two more days, thereby causing hurdles in rescue and relief work.



Figure 33: A disaster relief team and villagers look for survivors in the debris following a cloudburst in the Ukhimath area (Source: https://www.tribuneindia.com/2012/20120915/dun.htm)

2.1.11.2 Impact

Abnormally high precipitation induced/triggered landslides and debris flows in and around several villages, viz. Jua, Kimara, Bamankholi, Premnagar, Dangwari, Mangoli, Chunni, Salami and Giriagaon. There many houses were overrun by debris and a road connecting Kund with Ukhimath was washed away at Kund and Chunni. Many human lives were lost as also, numerous livestock; several houses and agricultural land and cowsheds were also raized. As per the published Situation Analysis - 21 September 2012 (Sphere India) report, 53 people died, 13 people went missing, approx 65 animals were found dead and several went missing. More than 300 families were affected by the flash flood/ cloud burst and women and children, were largely more vulnerable than others. The below table gives a damage summary:

TABLE 5: DAMAGE SUMMARY

Village Name	Human Loss	Public goods losses	Houses damaged	Livestock losses	Livelihood
Chunni	18	Road, electricity, communication, water supply, primary school partially damaged	31	35	Agriculture land and the standing crop has been entirely damaged.
Mangoli	09	Road, electricity, communication, water supply, primary school partially damaged	30	22	Agriculture land and the standing crop has been entirely damaged.
Kimana-Jiwa	09	Road, electricity, communication, water supply, primary school partially damaged	06	08	Agriculture land and the standing crop has been entirely damaged.

Bamankhola	04	Road, electricity, communication, water supply	06	14	Agriculture land and the standing crop has been entirely damaged.
Premnagar	05	Road, electricity, communication, water supply	07	17	Agriculture land and the standing crop has been entirely damaged.
Ukimath (Ration Depot)	04	Road and water supply	01	02	
Bhatwari	01	Road and electricity	22	08	Agriculture land and the standing crop has been partially damaged.
Giriya	03	Road, electricity, communication, water supply	03	05	Agriculture land and the standing crop has been entirely damaged.
Bedula	0	Road, electricity, communication, water supply	10	25	Agriculture land and the standing crop has been partially damaged.
Barangali	0	Road, electricity, communication, water supply	10	25	
Kirada Jakholi	5	Road and water supply	1	0	Agriculture land partially damaged.

Besides, there were several other villages, where even though no human losses had been reported yet large-scale agricultural land had either been damaged or the standing crop washed away. Damage assessments were not done by any agency. However, the NGO Coordination Committee advised its members to survey such villages and collect data, share information, arrange distribution of relief material and carry out follow-up with long-term rehabilitation work.

Manual counting of building footprints suggested that more than 100 buildings had been totally damaged due to debris flow run-out near Ukhimath town. Among these the share of Mangali village was 30, and Chunni 10 (Islam, et al. 2014). However, according to an agency, the NRSC (2012) approximately 126 buildings were fully or partially damaged. The most affected village was Mangali, where 32 buildings were damaged, whereas Chunni and Semla lost 12 each. Few other villages viz. Brahman Koli, Saari, Paldwari etc. together lost more than 70 buildings.

Road that connects Ukhimath town with district Rudraprayag was destroyed and blocked at few places. However, few minor connecting roads were also affected. The National highway (NH-109), from Rudraprayag to Gaurikund, and passing through this area was destroyed at several places. Similarly road between Kund and Ukhimath was blocked at a number of places by the materials transported by run-out of debris flow which also buried parts of Chunni and Mangali villages.

On the basis of preliminary landslide assessment of Ukhimath Landslide, 2012, National Remote Sensing Centre reported that a total of 7 km road was damaged due to debris flow (NRSC, 2012). As the rockslide and debris flow occurred during monsoon, it resulted in huge loss of standing crops. The largest damaged area measured about eight hectares near Ukhimath town. Also, nearly four hectares land with crops was identified from the post event imageries. Further, few more scattered fields (numbering more than 20), lying mostly in the southern portion detected visually and digitized to delineate the partial or total damage with respect to agricultural land.



Figure 34: Damaged houses in Mangoli village (Source: DMMC 2012)

2.1.11.3 Actions Taken

1. Disaster management rescue teams were among the first to reach the affected villages in Ukhimath and these were later accompanied by the Army, ITBP and some volunteers to carry out rescue operations.
2. The Chief Minister announced an ex-gratia of ₹ 3 Lakh for the families of the deceased. ₹ One Lakh was also announced for those whose houses had been damaged completely.
3. A total of 131 families comprising 550 persons were forced to leave their homes.
4. A total of 460 persons were rehabilitated in the Government Inter College, Ukhimath, while 90 persons were accommodated at Bharat Sewa Ashram, also in Ukhimath.
5. Many families living in the vulnerable areas shifted to safer places along with their nears and dears as the weather office predicted more rains in next 24 hours.

6. A coordination committee was set up by NGOs to take responsibility for data collection, information sharing, relief material distribution and follow-up with long-term rehabilitation work.
7. A relief camp was placed at the GIC Ukhimath campus, initially, 400 people were staying there and on 21st September 2012 there stayed 200 people.
8. Injured persons were also quickly evacuated by helicopter to Army's Base Hospital, Srinagar for advanced medical care.



Figure 35: Survivors being evacuated (Source: DMMC 2012)



Figure 36: Victims at a relief camp in Government Inter-College at Ukhimath in Rudraprayag; (Source: https://www.tribuneindia.com/2012/20120918/dun.htm)

2.1.11.4 Recommendations

1. Concrete breast wall with adequate provision of weep holes or perforated pipes for draining out excess water.
2. Provision for safe disposal of rainwater through a network of interconnected drains into the mainstream. This would help in stabilizing this site.
3. A number of severely damaged structures that are located in the highly vulnerable area are required to be removed immediately.

4. New constructions and other anthropogenic interventions are required to be avoided in the proximity of seasonal streams.
5. The anthropogenic intervention of all kinds be strictly regulated in the proximity of both seasonal and perennial streams.
6. Appropriate legislative intervention in this regard is a must.
7. There should be a thorough geotechnical assessment of affected sites of important existing houses where infrastructures are on the verge of damage and/or have been partially damaged by destructive debris flows.
8. Good lining/gradient/cleaning of road-side drains to prevent further water percolation/stagnation and erosion.
9. The large detached rockmass be broken into small pieces so that the area situated on the downslope direction is safe.
10. The well-anchored concrete wall has to be constructed at the toe of the landslide where maximum damage has been inflicted to the houses. It would help in protecting the rest of the houses in case of future instances of slope instability.
11. A burst wall with appropriate height is required to be constructed on the uphill side of villages around the road.
12. It is recommended that the debris and rockmass accumulated by the slide in the agricultural lands be cleared to enable masses to continue with routine agricultural chores.

2.1.11.5 Lessons Learnt

1. Unplanned construction of roads on the vulnerable slopes and unscientific disposal of the excavated debris have induced instability in the hill slopes and many areas in the proximity of the roads have become chronically prone to landslides.
2. Deterioration of hill agriculture and concentration of economic opportunities and other facilities in near by of the roads encouraged people to settle down by the roadside.
3. With the passage of time traditional practices of landslide management were forgotten and more and more people started to settle in areas vulnerable to landslides.
4. Limiting construction of roads in the hills: Alternative connectivity options, such as rope-ways would be better suited for the hills.
5. Traditional landslide management practices of the region are required to be studied and documented in detail.
6. The use of explosives in the fragile Himalayan terrain for infrastructure developmental works introduces instability in the rocks and therefore use of explosives should necessarily be banned.
7. Landslides have to be scientifically treated in their initial stages. This would ensure that the problem does not become chronic.

2.1.11.6 References

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2.1.12 KEDARNATH LANDSLIDE

2.1.12.1 Introduction

A devastating disaster struck Uttarakhand on 16-17 June 2013, when a cloud burst resulted in unprecedented rainfall causing fragmentation and melting of Chorabari Glacier and bursting of adjoining Gandhi Sarovar at an elevation of 3800 m. Consequent overflow of river Mandakini led to heavy floods in Kedar valley in Rudraprayag district. Heavy to very heavy rains continued in the area causing floods and landslides. A number of villages and settlements were badly affected. Township of Ram Bada, a transition point to Kedarnath, was completely obliterated, while Gaurikund and the market town of Sonprayag suffered severe damage and loss of lives. Towns like Kalimath, Ukhimath, Agustyamuni and Tilwara down the stream suffered heavy losses of lives and property. As per the eyewitnesses and technical inputs received from various agencies, the possible causes of the disaster could be summarized as:-

1. Collision of western disturbances with monsoon easterlies.
2. Excessive precipitation in a very short period.
3. Heavy erosion and the accumulation of large volumes of water and sediment in major river beds due to excessive rainfall.
4. Run off of loose debris, moraine and boulders with excessive force washing off all that came in its way.

2.1.12.2 Impact

The disaster caused heavy loss of precious lives and extensive damage to private properties and public infrastructure. More than nine million people were affected by the flash floods. The five districts namely, Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttarkashi were the worst affected. As informed by the State Government on 9 May 2014, a total of 169 people died and over 4,021 people went missing (presumed to be dead). Out of the total missing persons, 846 were from Uttarakhand and 3,175 were from the other states. The highest number of people reported missing were largely

from Uttar Pradesh followed by Uttarakhand and Madhya Pradesh, accounting for more than half of the total number of people reported missing. The suddenness of the flash floods coupled with the high velocity of flow laden with slurry, containing boulders washed away pilgrims and locals. Apart from flash floods, people were also reported to be killed by landslides, which buried them alive under huge debris and rockfalls. The difficult terrain and blockage of roads made it all the more difficult to provide necessary relief to the survivors stranded at isolated locations. The harsh weather conditions i.e. continuous rainfall, chilling cold and non-availability of proper shelter/clothes contributed to the misery endured by the survivors of the disaster. As per a report made available by the State Government, a total of 4,200 villages were affected, 11,091 livestock were lost and 2,513 houses were fully damaged. More than 70,000 tourists and 1,00,000 local inhabitants were stranded in the difficult mountain terrain of the upper reaches of the Himalayas. The damage was so enormous and extensive that it was termed by the media as a 'Himalayan Tsunami'.



Figure 37 Kedarnath before the flood after the flood (Source: India Disaster Report 2013)

Table 6: The extent of damage as reported by the State Government (Source: India Disaster Report 2013)

S. No	Item	Detail
1.	Number of affected districts	13
2.	Number of dead and missing persons (Presumed to be dead)	(169 + 4021)
3.	No. of houses damaged :-	
	(i) Fully damaged Pucca houses	2,119
	(ii) Severely damaged pucca houses	3,001
	(iii) Partially damaged pucca houses	11,759
	(iv) Fully damaged kuchha houses	394
	(v) Severely damaged kuchha houses	360
	(vi) Number of kuchha houses partially damaged	1,676
	(vii) Number of huts damaged	471
	(viii) Cowsheds damaged	361
4.	Animals lost :-	
	(a) No. of big animals lost	3,280
	(b) No. of small animals lost	7,811



Figure 38 Photographs depicting damages to highway & hydel project along Rishikesh-Chamoli highway (Source: Photo Courtesy: Dr. Surya Parkash, NIDM Dated 23 June 2013)



Figure-39: Photographs depicting the occurrence of landslides and subsidence along Rishikesh-Chamoli highway (Photo Courtesy: Dr. Surya Parkash, NIDM, Dated 23rd June 2013)

2.1.12.3 Actions Taken

1. Indian Air Force, the Aviation Corps of the Indian Army, several ministries/agencies of the Central Government, departments/agencies of the State Government, governments of other states, NGOs and corporate sectors, all helped in the evacuation/relief operations.
2. Government of India supported the State Government in carrying out its evacuation and relief operations by providing support to armed forces and paramilitary forces, including NDRF. The supply of aviation turbine fuel (ATF) for air operations was a challenge, which was successfully met by the combined efforts of the Indian Air Force and the Ministry of Petroleum and Natural Gas.
3. The government of Uttarakhand initiated massive rescue and evacuation operations with the help of various Central and State Government agencies.
4. The pilgrims were helped to board trains, buses or take their private transport/taxies etc. to their home stations.
5. All the essential supplies like food, drinking water, medicines, kerosene oil, solar lamps etc. were continuously provided by airdropping as well as by surface means. A total of 69 relief camps were run, where 1,51,629 pilgrims/ local residents have looked after.
6. Forty-three medical teams comprising of 313 doctors and 4977 para-medical staff, were deployed and essential medicines, bleaching powder and chlorine were regularly supplied.
7. The State Government established a Missing Persons Cell on June 27 at the Disaster Mitigation and Management Centre (DMMC) at Dehradun. The "missing persons" data was managed with the support of International Business Machines Corporation (IBM) professionals. Facebook and Twitter accounts were opened, where state-wise photographs and other accounts were posted which provided a very successful backup.



Figure-40: Evacuation by Army Jawans (Source: India Disaster Report 2013)

8. The Armed Forces carried out the rescue and relief operations with a remarkable sense of urgency and professionalism.
9. NDRF deployed 14 teams for the operation and rescued more than 9,044 persons.
10. ITBP deployed about 1,600 personnel for the operation and rescued more than 33,000 persons.
11. IAF deployed about 45 helicopters for the operation and rescued more than 23,500 persons.
12. Indian Army deployed 8,000 personnel including 150 Special Forces Troops and rescued more than 38,500 persons. 12 army helicopters were also deployed.
13. Twenty civil aircrafts were utilized by the State Government in the operations which evacuated approximately 12,000 persons.
14. Nehru Institute of Mountaineering, Uttarkashi, formed five rescue teams of 20 instructors and local youth and evacuated more than 6,500 stranded persons.
15. More than 1,35,000 persons were evacuated from the affected areas in the shortest possible time, notwithstanding widespread destruction of roads, difficult terrain and extremely hostile weather.
16. There may be overlapping in number of persons rescued by agencies mentioned above, as the same person could have been rescued by different agencies at various stages of rescue operation.
17. UAVs (Unmanned Aerial Vehicles) were deployed to scan the whole area of Kedarnath, mainly to identify the possible presence of survivors in the inaccessible areas.
18. As of 11 October, 2013 DNA samples of 319 dead bodies and 11 relatives had been sent for analysis.

2.1.12.4 Recommendations

1. Rautela, 2018 recommended that the number of tourists/pilgrims entering the hilly region prone to natural calamities needs to be controlled and visitor registers be maintained. This is particularly required in areas, where people have to trek, such as Kedarnath, Gomukh, Hemkund Sahib, Yamunotri and Chota Kailash- Kailash-Mansarovar etc.
2. A technological framework must be in place to prevent construction on unstable or steep slopes and encroachment on riverbeds. Also, all past encroachments be immediately removed.
3. There is a need for preparedness to remove all valuable assets from hazard-prone regions before monsoon and a mechanism to alert and evacuate locals at short notice through early warning systems.
4. NIDM (2015) recommended that the 'landslide risk micro zonation should be based on ground truth of landscape, geology, ecology, vegetation, soil characteristics, human settlements, landslide and flood history of the area'.
5. There is an urgent need to prepare such maps and use modern Geographical Information System-based tools for evaluating future risks in these vulnerable areas (Sati and Gahalaut, 2013).

6. Sundaramoorthy (2013), recommended creation of land use zoning regulations in the mountains based on landslide zonation maps and that all moraine-dammed lakes in the Himalayan catchments need to be mapped and their geotechnical stability assessed.

7. The State's Disaster Management Plan must lay out a detailed logistics setup required in the entire region with special emphasis on the hilly areas. These plans must cater to reserve stock of rations, essential supplies and fuel at pre-determined critical locations. The State should take advice of the defence services, trained in specialized logistic strategies and of the geologists in order to identify ideal locations and develop all weather helipads. The NDRF also faced acute problem in moving their heavy equipment in difficult terrain, therefore, suitable and easily transportable or mountable equipment must be provided for the search and rescue operations in the hilly terrain.

8. All disaster prone areas with high concentration of population, like Kedarnath, Badrinath and Chamoli, should have alternate evacuation routes which must be identified and maintained by the State.

9. A more effective integration of the voluntary agencies and nongovernmental organizations, at the district and local level, into the broader State level effort. The State Government should appoint a Nodal Officer in each district to maintain database of active NGOs in each district with their contact details and areas of intervention. Moreover, the Indian Disaster Resource Network (IDRN) database must be kept updated at all times as an important information resource.

10. The retired armed forces personnel may be encouraged to volunteer or contracted to provide their services and leadership in disaster response-related activities.

11. Though the deployment of hundreds of ambulances during the Uttarakhand disaster proved very helpful in saving lives, yet their mobility and effectiveness were hampered due to frequent roadblocks in the hill region and as a result, several injured were taken on shoulders across the roadblocks under very risky conditions. In coordination with other departments related to crisis management, the State Health Department should further strengthen its capability to provide public health and medical support during a disaster situation. The medical relief plans should therefore be integrated into the disaster response plans and resources earmarked accordingly. This should include fully equipped Response Teams with air ambulance support for immediate medical evacuation in tough terrains.

2.1.12.5 Lessons Learnt

1. For clearance of all hydro-power and other mega projects in ecologically sensitive regions like Uttarakhand, the Disaster Impact Assessment (DIA) should also be made compulsory besides Environmental Impact Assessment (EIA).
2. The existing emergency communication system be reviewed regularly to ensure last-mile connectivity during disasters.
3. Tourism-related development should not be allowed along the river banks.
4. Sectoral training in various disciplines of disaster management and capacity building at various levels including communities should be given due importance.

5. Stockpiling of essential items like food grains, blankets, medicines etc. must be ensured at block/ panchayat levels in designated areas for an emergency.
6. The community-based disaster management system at the local level must be given utmost importance and strengthened through appropriate training and awareness programmes.
7. The mechanism of the Incident Response System be established at relevant levels and be dovetailed into the disaster management plans. State and district agencies should build their command and coordination structures to support the local command and coordination structures during an emergency.
8. Need to integrate the contributions of volunteers and non-governmental organizations in disaster response at the State level. This integration would be best achieved at the district and local levels. NGOs should be engaged in the planning process for their involvement in a joint response.
9. The aspect of psycho-social support should be integrated into the medical plans for disaster-affected people.

2.1.12.6 References

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2.1.13 LAXMANPURI LANDSLIDE

2.1.13.1 Introduction

The July 2016 disaster at Laxmanpuri, which lies about 6 km from Mussoorie Town on the Mussoorie-Chamba road, is one of the dreadful landslide events in the history of Uttarakhand Himalaya. The Mussoorie township is one of the heavily urbanized hill stations in the Himalaya, where slope instability problems are regularly encountered (Peethambaran et al. 2019b). The Laxmanpuri landslide is located near the buildings of Civil Hospital Quarters (CHQ) and Mussoorie Veterinary Hospital (MVH).

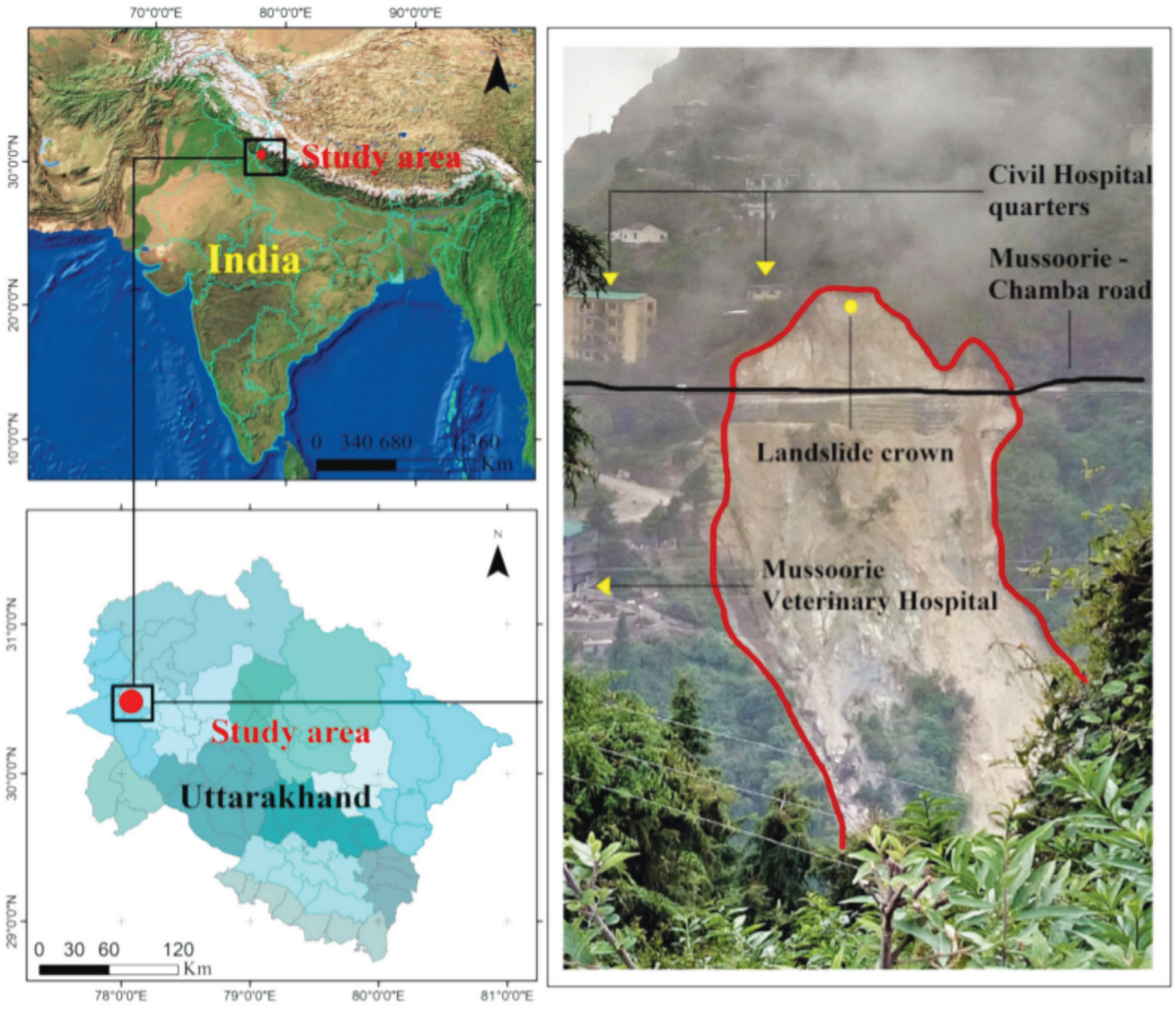


Figure-41: Location and panoramic view of Laxmanpuri landslide (Source: Peethambaran et al. 2021)

2.1.13.2 Impact

The Laxmanpuri landslide was a major incident as it is located in an important region of the township and was of serious socio-economic consequences. A large portion of the slope along with about 60m of the Mussoorie–Chamba road was washed away, thereby damaging several buildings in its close proximity. This landslide adversely affected the socio-economics of the township by severely damaged the buildings of CHQ and MVH. The first building of CHQ was constructed at least a decade ago (Figure-43a), while the second building came up in 2013-2014 (Figure-43b). The approach road for the MVH complex was also constructed in 2014. Further, the Google Earth images indicated that the construction for MVH complex continued till 2015. The first building of CHQ, which houses 24 families, had undergone minor settlement and needs repairing. The MVH was partially abandoned due to severe damages. The Mussoorie-Chamba road is an old route, which was widened only recently. The road segment was restored by constructing a reinforced concrete wall which costed around USD 0.27 Million to the Municipality of Mussoorie and also to the National Highway Authority of India.

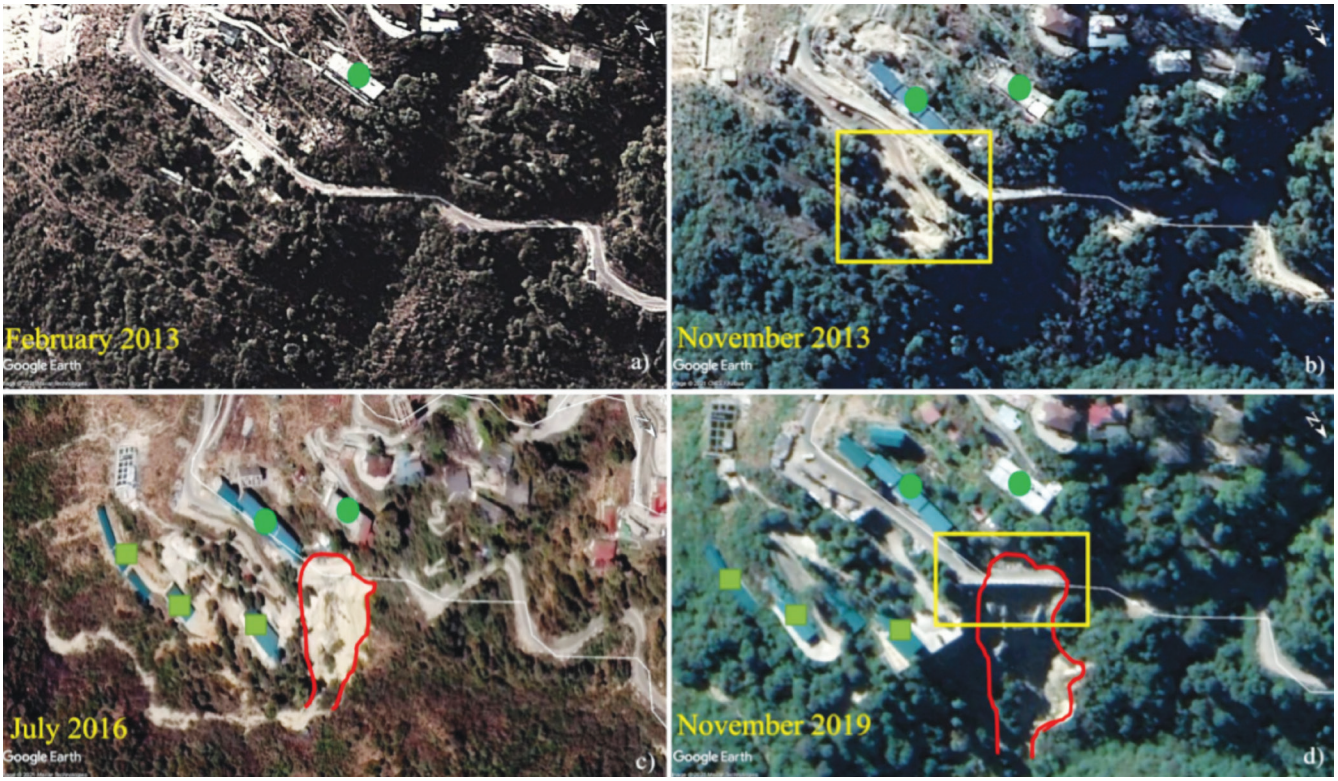


Figure 42: Pre- and post-event historic Google Earth images of the landslide site (green circles point buildings of CHQ, green squares point MVH complex, landslide is marked with red lines in c, d and approach road of MVH and retaining wall of road is marked in yellow boxes in respective images) (Source: Peethambaran et al. 2021)



Figure 43: (a) Crown portion of landslide above the road and (b) middle and lower reaches of landslide below the road level (Source: Peethambaran et al. 2021)

2.1.13.3 Actions Taken

1. The local administration sprung into action and evacuated the 30-year-old building of Municipal Council employees.
2. The administration shifted 12 families from the area to safer places.
3. Hospitals, PWD, ambulances and other emergency services were put on alert.
4. Peethambaran et al. 2021 conducted engineering geological investigation; he also carried out comparison based on pre and post-event stability analyses to derive its failure mechanism, causes and assessment of the present stability condition.
5. The National Highway Authority of India constructed a series of reinforced concrete walls across the slope at different levels to reinforce the damaged road section.
6. The Municipality of Mussoorie implemented similar measures to stabilize the left flank of the landslide.

2.1.13.4 Recommendations

The continuous disposal of wastewater from the CHQ and MVH over the slopes contributed in saturating the overburden. In monsoon rains, the overburden debris gets over-saturated inducing instability of the slope. Hence, the septic tank and wastewater discharge channels should be judiciously relocated to divert the water from the landslide vicinity. In view of accelerated developmental activities in this area, a systematic slope monitoring scheme shall be planned on the slope, particularly around the crown and in the northern portion, for surface and sub-surface monitoring by using ALS, TLS, inclinometers, piezometers etc., for assessing their probable activation time.

2.1.13.5 Lessons Learnt

1. Just above the landslide crown, a septic tank of the CHQ for 24 families is located and wastewater from this residential building is also being released onto the landslide-affected slope.
2. In addition, the wastewater from the MVH is also being released onto this slope through a drainage channel located just below the road level on the left flank.
3. The localization of shear strain in the vertical stress region might be attributed to the steepening of gradient for road widening.
4. The deep excavation practice of leaving the overburden unsupported is one of the reasons for initiating the landslide.
5. The unregulated practice of releasing domestic wastewater over the detachment zone of landslide might have created a temporary phreatic surface within the shallow overburden, causing deterioration of the equilibrium condition of the slope and eventually failure during rains.

2.1.13.6 References

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2.1.14 CHAMOLI DISASTER-2021

2.1.14.1 Introduction

On 7 February 2021, at about 10:00 in the morning, the upper catchment of Rishiganga river, a tributary to Alaknanda river, in Chamoli district experienced massive rock-ice avalanche.

The devastated site is located in Raunthi glaciated valley, a very remote area, severely damaging its infrastructure. Multiple blocks of rock, containing ice and snow dropped from about 5,600 m to about 3,800 m, a fall of almost two kilometers, and instantly fragmented further on their impact with the ground and caused huge flash floods and debris flows. This resulted in sudden rise in the water level of the Rishiganga and Dhauliganga rivers, triggering flash floods, and large debris flows. The rock and ice avalanches, travelled down the glacier at extremely fast pace and with very high energy momentum. On their way, they generated huge amount of dust, which got smeared on the valley side to the west of the valley. The study of satellite imageries, made available by Planet Labs, led to vivid understanding of the chronology of events.

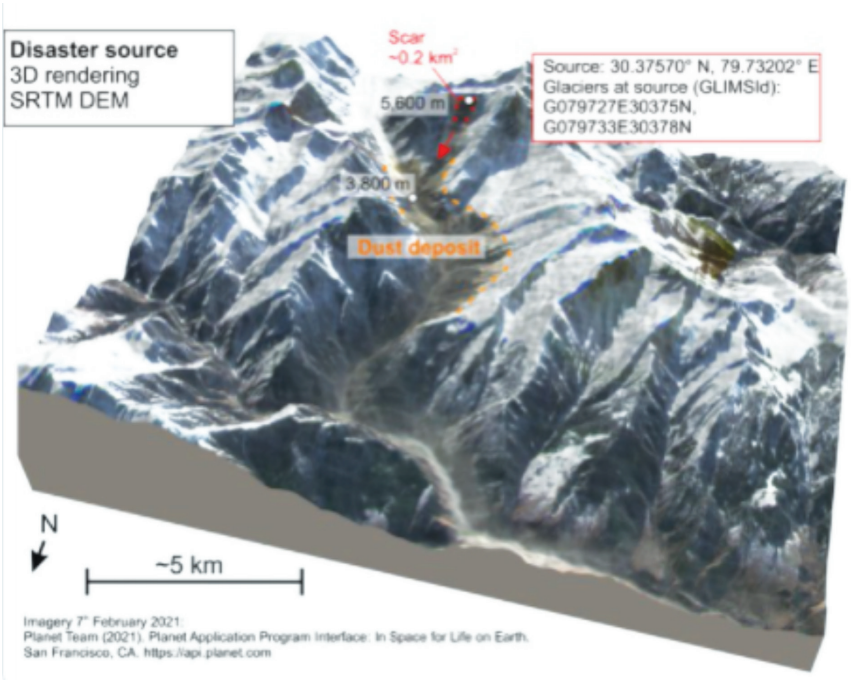


Figure-44: 3D rendering of @planetlabs image showing the source of the Uttarakhand disaster (Source: Scott Watson, 7th Feb 2021)

2.1.14.2 Impact

1. As per the published report by the Ministry of Home Affairs, Disaster Management Division (National Emergency Response Centre), out of 204 missing persons, bodies of 80 persons (including 16 from Tapowan Tunnel) were recovered till 23.03.2021 and 124 persons were still missing.

2. The catastrophic ice-rock avalanche that got transformed into mud and debris flood speedily descended the Ronti Gad, Rishiganga, Tapovan and Dhauliganga valleys in Chamoli district, Uttarakhand.

3. The 13.2 MW Rishiganga Hydroelectric Project (HEP) near Raini Village was completely destroyed.

4. Excessive deposition of sediments in the river channel, resulted in the rise of river bed by approximately 11m to 13m in the affected streams.

5. Approach road & BRO bridge at Raini village was washed away.

6. NTPC HEP at Tapovan was adversely affected (sediment deposition in desilting tanks, HRT & Adit tunnels filled with thick debris, 11-13 m).

7. Five suspension bridges were washed away.

8. Service roads on either side of river Dhauliganga were damaged

9. Some residential buildings & a temple close to the banks of the rivers were destroyed.

10. Affected villages:13 due to damage of utility supply lines (electricity, water and bridges)

11. Domestic: Animal loss: 184 [Four big animals from village Peng and 180 small animals from village Juvagwad]

12. The event also affected the population with psycho-social impacts due to the loss of their nears & dears as well as families' bread earners.







Figure 45 Photographs depicting damages

of Rishiganga Power Project







Figure-46: Photographs depicting damages of Tapovan Power Plant

2.1.14.3 Actions taken

As per the published Situation Report on the Glacial Outburst at Reni in Chamoli District Uttarakhand as on 17.03.2021 up to 1830 hrs by Ministry of Home Affairs, Disaster Management Division (National Emergency Response Centre):

1. The Situation was being monitored on 24x7 basis by Central Government at the highest level. Hon'ble Prime Minister himself monitored the situation closely.

2. Deployment of Manpower and Resources by Central Government:

TABLE 7: DEPLOYMENT OF MANPOWER AND RESOURCES BY CENTRAL GOVERNMENT

a)	NDRF	02 Teams with all necessary rescue relief equipment and term of dog squad
b)	ITBP	Standby
c)	SSB	Standby
d)	Army	Standby
e)	Navy	01 Deep Diving team Standby in New Delhi
f)	Air Force	05 Helicopters at Sarsawa IAF Stn. Standby
g)	BRO	03 JCB, 01 Wheel Loader, 02 Hydro Excavators (20T/30T)

3. The district administration, police and disaster management departments of State Government along with all central agencies were deployed for rescue and relief work. 02 teams of SDRF, 01 Medical team with 04 ambulances of State Health Department were deployed.

4. Electricity and Water supply were restored in all 13 villages. 03 trollies were made functional on river Dhauli Ganga in Tapowan and Reni for connecting Bhangyul, Juvagwad and Jugju village.

5. Muck removal in the Intake portal of SFT tunnel NTPC project silt flushing tunnel (SFT) Adit was carried out. Dewatering pumps were continuously used.

6. An artificial lake was formed on the upper ridge of Rishiganga River. The water flowing through the channel formed at the mouth of the lake widened to approx 60 feet and the channel was being constantly monitored.

7. Team of Snow & Avalanche Study Establishment (SASE), National Remote Sensing Centre (NRSC), National Technical Research Organisation (NTRO) and Defence Research and Development Organisation (DRDO), Geographical survey of India and Wadia Institute of Himalayan Geology (WIHG) provided all necessary technical assistance including satellite images at regular intervals.

8. Intercom communication was established inside the tunnel.

9. Satellite communication system established between rescue site and control room at Raini village for surveillance of river water level.

10. An alarm and Hooter system were installed and made operational for an early warning system.

11. A Medical camp and Public Information Centre were operational.

12. On 24.02.2021 the depth measurement of artificial lake at multiple location was completed successfully by deep divers of Indian Navy. The depth of the lake measured approx. 46 Meters in the middle of the lake with gradual reduction towards the inflow point. The team observed that the rate of outflow is higher than that of the inflow and the water level in the lake is gradually reducing.

13. Construction work of completely damaged motor bridge at Joshimath to malhari axis completed by BRO on 05.03.2021.

14. For the financial year 2020-21, Rs 1041.00 crore were allocated to the State of Uttarakhand under the State Disaster Risk Management Fund (SDRMF). The both installment of the Central share amounting Rs. 937 Crore was released to the State Government.

2.1.14.4 Recommendations

1. Need to foster and implement very first agenda of PM's 10 Point Agenda on DRR viz "All development sectors must imbibe the principles of disaster risk management".
2. The natural dam created in front of the lake seems to withstand the hydrostatic pressure generated by the accumulated water. However, it's suggested to continuously monitor the discharge of lake waters.
3. Any evidence of piping from the debris dam body needs to be closely monitored.
4. The stability of debris dam near the crash zone needs to be monitored for the failure in the forthcoming summer.
5. Raunthi Gad exhibit steep gradient and fairly narrow valley. Re-occurrence of similar incident could be very dangerous. Therefore, as an immediate measure, vulnerable zones of rock/ice avalanche zones may be identified and effective communication may be put in place.
6. To augment the observational network, fill the data gap areas and enhance forecasting services, 3 DWRs are proposed to be installed in Uttarakhand under Integrated Himalayan Meteorological Programme(IHMP). Out of these; 1 X-band DWR has been commissioned in Mukteshwar, Nainital. Installation of 2 at Surkanda Devi, tehri is in progress and of 3 in Landsdowne will commence shortly.
7. IRS and Unified command system to be followed.
8. Need to look for alternative options for the power generation such as Gharat (water mill) or solar etc.
9. During HEP construction projects, escape tunnels/shafts may be kept as escape routes.
10. Controlled blasting method may be adopted for construction of tunnels/road widening as area is vulnerable to landslides.
11. Each HEP should setup u/s monitoring & warning systems for the glaciers that feed this river system.
12. To revise and update the DDMP on regular basis with multi HRVA studies. Also to prepare the DM plan & Emergency Action Plan (EAP) of small & big HEP's.
13. Capacity building & training to the local people (villagers) should be given from time to time.
14. Training module should include mock drill, learning of some basic instruments like wakie talkie, cellphone, techniques to escape and rescue people.
15. National Disaster Management Agency (NDMA) has partnered with the Swiss Agency for Development and Cooperation (SDC) along with national experts from concerned Indian

institutions for the development of the National Guidelines on Management of Glacial Lake Outburst Floods (GLOFs). These guidelines aim to enable concerned ministries or departments of State/UT, central governments and other stakeholders to take concerted action for preparedness, prevention, mitigation and response to GLOFs. These Guidelines also emphasize awareness and capacity building of the relevant stakeholders.

16. Data management and data archiving should be emphaised which helps to study the pattern analysis.

2.1.14.5 Lessons Learnt

1. There is a need to focus on the disaster risk impact assessment, especially for the major projects like that of hydroelectric power projects.
2. Robust monitoring of glaciers would have been handy to provide early warning.
3. Lack of assessment on monitoring the probable impact of climate change and global warming on the glaciers.
4. High-resolution mapping of the affected area in the future can be useful in understanding the spatial and temporal changes due to the event as well as monitoring the area for the development of the affected area after the event.
5. Identification of the affected areas from the model can help plan the early warning systems and evacuation protocols, which can be made standard for other locations that may face a similar danger.
6. Every dam can help moderate flood, as long as there is space in the dam to absorb/ store flood water.
7. Landslide need to be identified and mitigated to avoid future disasters.
8. The Chamoli disaster sadly confirms that many hydropower companies operating in the Himalayas are not doing enough to survey and monitor the increasingly volatile alpine environment.
9. Communities are key for such preparedness and response. Not only are small communities agile and can mobilize quickly, but they also know their own populations best. Data for risk prediction and risk prevention must be increased.

2.1.14.6 References

1. Situation Report on the Glacial Outburst at Reni in Chamoli District Uttarakhand https://ndmindia.mha.gov.in/images/2021/SitRep17032021.pdf
2. Lessons from the Uttarakhand disaster, 21 March 2021 https://www.indiawaterportal.org/articles/lessons-uttarakhand-disaster
3. Webinar Report Lessons from Chamoli Disaster 2021, 26 July 2021, Geo-meteorological Risks Management Division, NIDM
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2.2 HIMACHAL PRADESH

The state of Himachal is prone to various hazards both natural and manmade. Main hazards consist of earthquakes, landslides, flash floods, snowstorms and avalanches, droughts, dam failures, fires – domestic and wild, accidents – road, rail, air, stampedes, boat capsizing, biological, industrial and hazardous chemicals etc. The hills and mountains of Himachal Pradesh are liable to suffer landslides during monsoons and also in high-intensity earthquakes. The vulnerability of the geologically young and not so stable steep slopes in various Himalayan ranges, has been increasing at a rapid rate in the recent decade due to inappropriate human activity like deforestation, road cutting, terracing and changes in agriculture crops requiring more intense watering etc.

Landslides are known to play havoc causing death and destruction. In India, Western and Eastern Ghats, Jammu and Kashmir, Himachal Pradesh, Uttranchal and North Eastern Parts as well known for landslides. Delineation of landslide-prone areas requires a large data set. Various forms of landslides are slumps; debris or rock slides, debris falls or rock falls. Various factors influence the landslides: steepness of slopes, saturation by heavy rains or melting snow and ice, rocks vibrations, excess load from embankments, fills and waste dumps, changes in water content, frost effect, weathering of rocks, effect of ground water and change in vegetal cover.

The hills and mountains of Himachal Pradesh are liable to suffer landslides during monsoons and also in high intensity earthquakes. The vulnerability of the geologically young and unstable steep slopes in various Himalayan ranges, has been swiftly increasing in recent decades due to inappropriate activity, such as deforestation, road cutting, terracing and changes in agriculture pattern requiring more intense watering.

TABLE 8: LANDSLIDE PRONE AREAS OF HIMACHAL PRADESH (SOURCE: LANSLIDE HAZARD ZONATION ATLAS OF INDIA)

District	Severe to very high	High	Moderate to Low	Unlikely	Total Area (Sq km)
Bilaspur	216	842	83	1	1142
Chamba	2120	3829	351	70	6370
Hamirpur	0	851	204	45	1100
Kangra	123	3698	1233	557	5611

Kinnaur	868	4956	498	0	6322
Kullu	1820	3512	65	3	5401
Lahaul & Spiti	127	11637	1825	2	13591
Mandi	968	1978	826	98	3870
Shimla	893	3345	767	14	5019
Sirmaur	95	1805	614	228	2742
Solan	556	1118	157	79	1910
Una	2	678	517	311	1508

Hazard risk map of the state depicts that the area of the state falls under the three categories of hazard proneness viz. low, medium and high hazard. Most of the area under the state of Himachal Pradesh is under high hazard. Figure-45 below shows the result obtained from three different methodologies that is as per the methodology adopted in BMPTC vulnerability analysis, as per Expert's knowledge and as per Analytical Hierarchical Process.

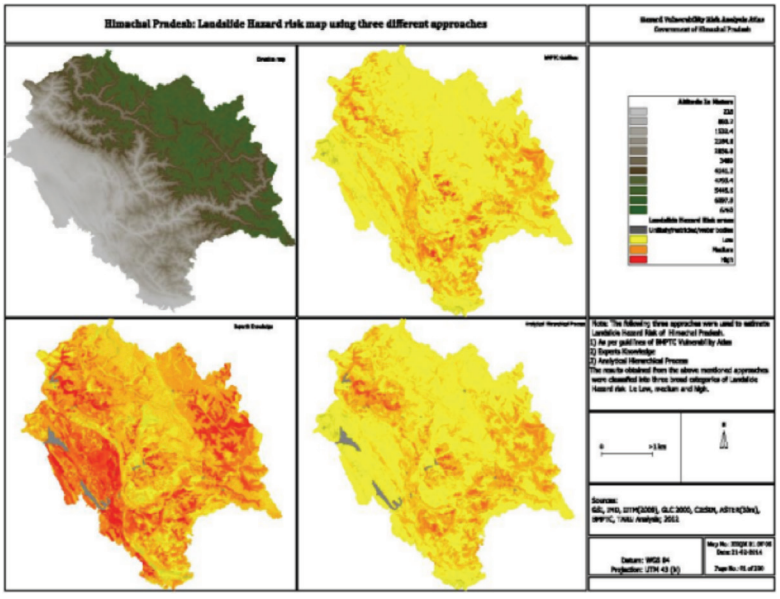


Figure-47: Landslide Hazard Risk Zone Map of Himachal Pradesh
(Source: https://hpsdma.nic.in/admnis/admin/showimg.aspx?ID=2671)

MAJOR LANDSLIDES

- 1968 – A bridge was washed out in the Maling landslide in Kinnaur which is still active
- 1982 – Sholding Nullah landslide caused collapse of bridge
- 1989 – A landslide at Matiana in Shimla on Hindustan-Tibet road-killed 40 persons
- 1993 – Huge landslide damaged road and blocked the Sutlej

- 1995 — A massive landslide in Luggar-Bhatti area of Kullu district claimed over 100 lives
- 2004 — Nine labourers were buried alive under a landslide at Mulgi bridge near Basantpur in Shimla
- 2008 — A landslide at Nehru Kund near Manali killed six persons
- 2015 — Falling rocks crushed 10 pilgrims in Manikaran in Kullu
- 2017— A sinking hill buried 46 people at Kotpuri near Paddar in Mandi

Below is a brief discussion on some of the significant occurred landslides in Himachal Pradesh based on the available archived data and the studies conducted so far:

2.2.1 SNOWDON LANDSLIDE

2.2.1.1 Introduction

The slide of February 1971 at Snow Don, Shimla, located in the Lower Himalayas, presents the first case record from India of a thoroughly investigated landslide in detritus. The landslides in detritus are difficult to analyze because it is not known whether the in situ shear strength of detritus along the surface of sliding is governed by the overall detritus material as such (comprising both the hard rock inclusions and the matrix soil) or by the matrix soil alone. The case record throws light on the choice of shear strength parameters that govern the first-time slide in detritus materials.

2.2.1.2 Impact

Destruction of a six-story medical college under construction.

At Snowdon, a 21.5 m high 37° slope had supported satisfactorily a dispensary and a hospital building at its top, for a number of years, without any noticeable signs of distress. Encouraged by the steady performance of the slope, a six-storeyed Medical College building (Phase I) was built between May 1970 and December 1996, 14 m away from the toe of the slope. This building, when built was 22 m high and occupied 39 m x 14.6 m of the plan area. An extension of the building, between the main building and the upper slope was planned by back cutting and initialed as Phase II construction. The attempted excavation into the slope from the toe inwards led to minor cracking of the dispensary building and eventually developed a well-defined landslide in February 1971, following the monsoon season.

2.2.1.3 Actions taken

1. A detailed geotechnical investigation of the stability of the slope was taken up in March - April 1971.
2. Simultaneously the mapping of the slide, drilling, sampling, testing etc., were done and the movements of the slide were carefully monitored, initially by recording observations of the surface markers and later by deflection standpipes installed at selected locations within the slide mass.
3. Casagrande open type Piezometers were installed for making piezometric observation.
4. Using the shear strength parameters estimated by the above analysis, a RCC counter fort retaining wall was designed and constructed at the toe of the slide.

5. The denuded slope was vegetated by resorting to Asphalt-Mulch Technique of vegetation turfing and in some areas by coir netting.
6. The surface drainage was accomplished by a system of catch-water drains.

2.2.1.4 Recommendations

1. In case of constructions in the sliding or sinking area, only two storeys will be compoundable subject to the recommendation of the geologist.
2. The town, which was built for a population of just 25,000 in the early 20 century, today houses close to 3,00,000 people. And, as against the recommended density of 450 persons per square hectare in hill settlements, the town's localities have densities ranging from 2,500 to 3,500 persons for the same area.
3. Although the whole Shimla is equally vulnerable but the poor population is living in the most vulnerable locations i.e. on slopes and sinking zones. Their exposure makes them more vulnerable to face the effects of an earthquake
4. Most of the town is built on slopes between 45 and 75 degrees. Some 90% of central Shimla, built on a 60 degrees slope, is covered with buildings which are four to five stories high. In the event of an earth tremor, the devastation could be enormous, with buildings on slopes steeper than 45 degrees collapsing in a chain. In the hills, it's imperative to build on pillars that rest on rock strata. People raise pillars for buildings which are embedded in loose soil because the cost of construction goes up substantially if deeper pillars are to be made.
5. Seismic Micro-zonation will provide a technical and scientific insight into seismic vulnerability of city in detail which will further provide guidelines and recommendation which would be location specific. For this purpose it is required to hire any technical agency which could perform the seismic micro-zonation.
6. Recommend demobilisation of the IRT, when appropriate;
7. Recommend measures for assuring safety of responders and to assess or anticipate hazardous and unsafe situations and review it regularly.
8. To the extent possible, preventive measures as recommended in the preparedness and mitigation document of DDMAP should be undertaken to improve departmental capacity to respond to a disaster.

2.2.1.5 Lessons Learnt

1. The landslides cannot be predicted, there is no area that can be identified as landslide proof. This natural calamity is not specific in occurrence i.e. no specific time be given. The landslide takes place so suddenly sometimes when people have no chance to defend themselves. The event leads to damage of all infrastructure, houses etc., As the supply of electricity with the water is off. It is very difficult to carry out relief operations in these area. There is general and earnest need to create awareness about precautions to be taken before during the landslide., In all the areas where people and cattle live.

2. It is necessary to have relief and rescue machinery always alerts of all levels including Village tahasil and Dist. level. machinery, equipment and trained personnel are necessary for removing debris and rescuing peoples.

3. In the absence of this one cannot save many lives & loss of infrastructure, houses can be avoided by building them resilent.

2.2.1.6 References

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2. Bhandari, R. K., (1986) Slope instability in the fragile Himalaya and strategy for development, Annual Lecture delivered in IIT Delhi, 16 December, 1986.

3. Sirvastava J.P, 1957-581 Report on the investigation of foundation condition of stability of hill slide on the Snowdon hospital of Himachal Pradesh, Simla.

2.2.2 NAINA DEVI LANDSLIDE

2.2.2.1 Introduction

Raju and Jalote (1980) reported the Naina Devi landslide. It rained excessively during the monsoon of 1978. A crack was observed in the floor of the temple warehouse on 1 August 1978, following heavy rains on the previous day. On the following days, a number of cracks were observed in the surrounding areas, including the bus stand. Subsidence or vertical displacement of from 15cm to 30cm was observed on 6th August and an appreciable widening of the cracks was observed on the following days. The lower spur in the valley, adjacent to a small stream, is reported to have slid on 24 August, following heavy rains. The landslide was a result of the unprecedented heavy rains that oversaturated the overburdened material, resulting in increased weight and pore water pressure and reducing the cohesion and shear strength of the material, especially at the interface of the claystone and overburden. The Naina Devi range, where the temple and town are located, is a linear hill range constituting the southwestern limb of an anticline. The lower Siwalik formations, comprised of sandstone and claystone, occur on the ridge. The length of the area affected by the slide is 880m and the width is 480m. The slide material is mainly composed of sandstone debris of various sizes, embedded in sandy soil overlying purple claystone. The claystone dips towards the valley at angles ranging from 30° to 35° (Figure-40). The whole village and the bus stand were originally constructed on this overburden. The area has been stable for a very long time.

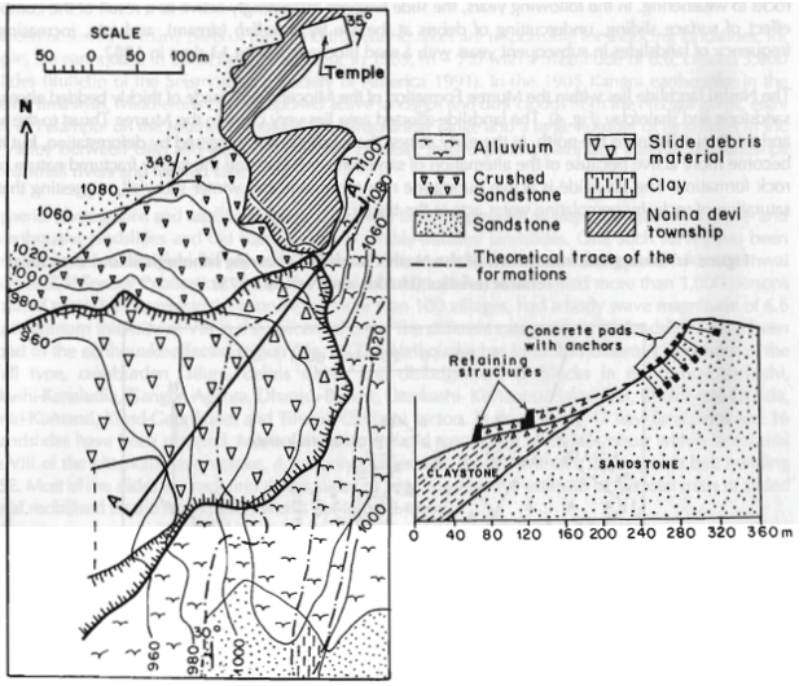


Figure-48: Geological setting and remedial measures of the Naina Devi landslide (Source: Krishnaswamy 1980)

2.2.2.2 Impact

This slide damaged the houses located on the spur and blocked the stream's course. On the morning of the 25, a widening of the fissures at the bus stand was noticed and the groundmass started moving, slowly threatening the structures. All inhabitants abandoned their houses and moved to safer places in the town. The downward movement of the ground started at seven a.m and, in a span of two hours, the whole mass of debris, 143 structures belonging to 46 families and a portion of the road and some portions of the steps to the temple were carried down the slope over a distance of 150m.

2.2.2.3 Actions taken

1. All inhabitants abandoned their houses and moved to safer places in the town.
2. Recommendations were implemented by the Govt.

2.2.2.4 Recommendations

1. Remedial measures were suggested by the Geological Survey of India (GSI) team (Figure-48) in order to stabilise an area of over 20,000sq.m.
2. Retaining structures at locations shown in the figure-48, with weep holes to allow seepage, were suggested.
3. On steep slopes, where circular failure had occurred in fractured and weathered sandstone, concrete pads with suitable anchors into massive sandstone were suggested.

4. The easing of the slopes, small retaining walls and proper drainage were recommended for the eastern slopes.
5. Methodology of landslide damage assessment.
6. GIS based hazard, vulnerability and risk assessment.
7. Deterministic and Probabilistic stability analyses of complex natural and manmade slopes and landslides.
8. Scientific Design of surface and subsurface drainage systems and field evaluation of their efficacy.
9. Innovative technologies for mechanized construction of complex subsurface drainage networks.

2.2.2.5 Lessons Learnt

1. Tree roots play an important structural role on hill slopes. The roots, winding through the soil and often penetrating bedrock, add strength to the soil in the same way that steel rods reinforce concrete. When trees are felled, these roots begin to decay; the hill slope gradually loses its resistance to failure, resulting in landslides. Studies in the Western Cascade Range of Oregon, USA, on clear-felled, unstable and steep hill slopes, revealed that landslide erosion was 2.8 times greater on such slopes than on comparable forested land (Haigh 1984).
2. It is estimated, on the basis of satellite imagery, the area covering the hill districts (Kumaon and Garhwal) of Uttrakhand, has only 37.5 percent of its area under forest cover. The deforestation of Uttarakhand has occurred very rapidly in the last five decades, finally reaching alarming proportions and giving birth to the Chipko Movement; a movement of the people to save the forests. Deforestation in the Uttar Pradesh Himalayas has also increased floods in the Gangetic plains.
3. Road construction has been another conspicuous contributor to deforestation, causing massive landslide problems.
4. New hill roads have been built quickly and cheaply across uncharted territory, ancient landslide zones and active scree slopes.
5. Explosives have been used liberally and these have opened up fissures in the fractured rockslopess.

2.2.2.6 References

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2.2.3 KINNAUR LANDSLIP

2.2.3.1 Introduction

A massive landslide knocked down the Solding bridge in Kinnaur district in early morning on July 12, 2000. The districts of Shimla, Solan, Sirmaur and Kinnaur had continuous rain for the second day today, flooding the rivers and nullahs and also triggering landslides at many places. Again on July 17, 2000 — At least 16 persons were killed in rain and landslide related mishaps in Himachal Pradesh.

2.2.3.2 Impact

The main bridge was washed away in the previous flood in the area and the old suspension bridge was being used for the movement of vehicular traffic. Reports said heavy boulders started falling on the suspension bridge at about 2 am and the iron ropes broke. In the meanwhile, a massive landslide washed away the bridge.

Even the suspension bridge was closed to heavy vehicles for the past three days as one of its ropes had got damaged when a boulder fell on it.

Many places on the highway witnessed landslides because of heavy rain. The highway was also closed at Neogalsari due to debris.

Due to landslide on July 17, 2000 four children were injured seriously when a portion of their school building collapsed at Guggaghat.

Traffic on the Kalka-Shimla national highway and most link roads remained blocked for long hours following huge landslides.

Though traffic, remained suspended for over five hours when a landslide struck the national highway near Mandsar village. Traffic also remained suspended for nearly two hours near Jabli where several landslides blocked the Kalka-Shimla road below the Cosmo Ferrities factory. Hundreds of vehicles with over, 5,000 passengers remained stranded during the road blockade.

Scores of trees were uprooted and a transformer of the HPSEB was damaged when a huge pine tree fell on it near Dharampur.

Twenty heads of cattle were washed away and 30 families living in Fauji Colony, near Baddi, had to be evacuated to safer places following the colony's inundation by the heavily swollen Sirsa. A 325 metre-long bridge on this river was also washed away.

The torrential rains that lashed this district during the past 12 hours had taken a heavy toll of public and private property. Most of the roads and some bridges had been damaged at several places. The district administration was assessing the loss which was being described as very heavy.

Traffic on the Kalka-Shimla rail section was suspended after landslides blocked the tracks at Koti, Gumma, Sanwara, Salogra and Dohri Dewar, near here.

2.2.3.3 Actions taken

1. Rescue teams were at work at the landslide site in Kinnaur district's, trying to pull out survivors from under debris. The government asked the Deepak project of the Border Roads Organisation to construct a bailey bridge at Solding to restore traffic on the highway after July 12th 2000 landslide.

2.2.3.4 Recommendations

1. It recommended that no new cities be built in the environmentally sensitive area, new dams should be stopped and any construction should be prevented in the wetlands and river catchment areas.

2. It also recommended a ban on the expansion of tourism and on mining.

3. Slope cutting has to be carried out scientifically, keeping in view the nature of strata to ensure stability. Instead of large-scale vertical cutting of the fissured and fragmented rock strata, bridges should have been constructed.

4. Failure to provide proper drainage, particularly cross drainage, also aggravates the problem of landslides, as storm water floods the road and then flows in a torrent downhill, creating new gullies by eroding the slopes. The dumping of debris on slopes adds to the problem, as it is washed down into 'khads' and streams, which often change course due to the burden and cause massive damage in the areas downstream.

5. The debris generated during excavation is mostly dumped on slopes and this is the main cause of increasing landslides in urban areas even as precipitation is declining.

2.2.3.5 Lessons Learnt

1. Prevention and training are key points,

2. Key measures by the authorities should be taken as early as possible and

3. The centralization of the deceased in one location demonstrated greater effectiveness identifying victims and releasing the bodies back to families.

4. It is not possible to altogether prevent geological events like landslides but their frequency, scale and destructive potential can be limited by restricting human activity in the mid and high hills, ensuring proper environmental safeguards while undertaking construction of roads and other development projects and strictly enforcing building laws in vulnerable zones, besides improving and expanding the forest cover.

5 The states should also give preference to construction of traffic tunnels while constructing roads instead of excavating hills over large stretches.

2.2.3.6 References

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2. http://ddmakinnaur.hp.gov.in/page/History.aspx

3. The Tribune news article, SHIMLA, July 172000; 16 killed as rain lashes Himachal. https://www.tribuneindia.com/2000/20000718/main6.htm

2.2.4 KOTRUPI LANDSLIDE, MANDI

2.2.4.1 Introduction

In the early hours of 13/08/2017 (at around 00.15hrs.), a calamitous landslide occurred at Mandi - Jogindernagar - Pathankot National Highway (N.H.-154), near Kotrupi Village, Tehsil Padhar, District

Mandi, Himachal Pradesh. As per the local community, the landslide has a return period of 20 years. The landslide was first initiated in August 1977.



Figure-49: Kotrupi Landslide 2017 (Source: GSI)

2.2.4.2 Impact

The nasty incident graved two buses of Himachal Road Transport Corporation and took forty six human lives. Several cattle beside wild fauna were also got buried, though their numbers were unknown. The few agriculture terraces/ fields, bikes and vegetable vehicles were also in the victims of landslides. The structures, infrastructures and other losses in the event were as follows:

- 7 houses were damaged, resultant 7 families were rendered homeless.
- Livestock including 6 cows, 2 oxen, one goat and one calf buried under the debris.
- Approximately 300-350m stretch of road was damaged.
- A bridge of 25-30m in length devastated.
- Hutments (3-4) on upslope were destroyed.
- 30 bigha of land of 10 families and crops were also washed away during the incidence.
- Cattle shades were also damaged.
- Loss of livelihood of the villagers dependent on agriculture and livestock.

NIDM team led by Prof. Surya Parkash, Head, Geo-meteorological Risks Management Division had a field visit during February 2021 and consulted with the local disaster management authorities and local communities. Local communities were cognisant about the vulnerability of the slope.



Figure-50: Google Satellite Imagery of March 2017 showing Agricultural Land at Kotrupi Landslide



Figure-51: Now Devoid of Agricultural Land and Cattle Shades at Kotrupi Landslide

The disaster wreaked havoc on the passengers of two buses of Himachal Pradesh State Transport that were designated from Katra to Manali and Manali from Chamba. The first bus (Katra to Manali) had 8 to 10 passengers while in the latter one 40-45 passengers were boarded. As per the local authorities, the debris washed away two buses of Himachal State Transport along with a few other vehicles. The bus slide down 400-500 meters below the road with debris. The bus was vertically in the debris and passengers were alive until the bus completely merged in the mound of debris. As per the rescuers and locals, the bodies of the children were found with their hands on their heads.

2.2.4.3 Actions Taken

1. Local residents of the area informed the relevant authorities about the incident. Local authorities from nearby areas rushed to the site as soon as they received the information about the mishap. The rainfall and the darkness hampered the inspection of the situation.
2. Local authorities along with villagers tried to rescue the persons stranded in the bus with help of torches and vehicle lights. The actual gravity of the situation became clear only in the early morning when the dawn broke out.
3. On the direction of Deputy Commissioner, Mandi line departments of the district including the Police department, fire services and Medical Services besides the local community rushed to provide a helping hand in the operation.
4. District administration approached the Army, NDRF, SDRF, at Reserve Police forces for the operation. Teams of the NDRF and Indian Army rushed to the spot-on.
5. The whole area has been covered with several feet of mud and big boulders. Traffic was diverted from both sides of the National Highway. Heavy earth-moving machinery was deployed at the gorge where the two buses lay buried under a heap of debris.
6. 3 Poclains, Hydra, crane, 2 bulldozers, 4 JCBs, hydraulic jacks, sledgehammers and power saws were used to cut through steel and concrete to rescue the inhabitants trapped under tons of debris and to remove the dead bodies.
7. Relentless rescue and clean-up operations continued for many hours.
8. Forty-six bodies were recovered and five injured rescued were in a day-long operation. Amongst the recovered bodies, 43 are from the ChambaManali bus and three from the Manali-Katra.
9. All the line departments, Emergency Response Functionaries and Social Emergency Response Volunteer (SERVs) joined hands for the response operation.
10. Operation of search and rescue for victims trapped in landslide was carried out by District Administration, police and National Disaster Response Force (NDRF).
11. Social Emergency Response Volunteer helps in Transportation of injured persons and causality from incident site to medical outpost.
12. Police, Traffic polices and Social Emergency Response Volunteer helped in managing and monitoring the traffic situation and the presence of a huge crowd and vehicles, apparently volunteers from across Mandi who had rushed to the site on hearing the news of the tragedy.
13. The victims and families from the villages that were declared unsafe, shifted to the nearest government schools/residences, community buildings and Panchayat Ghar by the District Administration with their household with the help of Social Emergency Response Volunteer.
14. Blankets, clothing and other necessary items were distributed to the victims and the affected families and were shifted to Emergency Shelter.
15. Social Emergency Response Volunteer helped in the arrangement of food and drinking water supplies to search & rescue operation teams working on the incident site.

16. Few SERVs female members prepared and brought home-cooked food along with drinking water for affect family & rescue teams from water streams far from the incident sites.



Figure-52: Glimpse of Rescue and Response of Kotrupi Landslide, Mandi (Source: DDMA Mandi)

The district administration as per the norms provided relief to the kin of the victims. The total amount of Rs.2,98,03,966/- was expensed on relief and miscellaneous expenditures (Source: DDMA Mandi, Himachal Pradesh). A relief of Rs.10,000/- each to the next of the kins of deceased was provided by SDM Joginder Nagar and SDM Padhar.

2.2.4.4 Recommendations

As per observations during the field visit, the remedial measures used to stabilize the slope include

I. Construction of gabion wall,

II. Check dams,

III. Precast concrete pipes,

IV. Steps and plantations



Figure-53: Remedial measures adopted at Kotrupi
(Source: Parkash and Kathait 2021)

V. Establishment of Early Warning System Internet of Things (IoT) based Early warning system was established on the site by IIT Mandi for monitoring purposes (Figure 54 and 55). The IoT is a powerful concept of interacting with the physical world through a network of natural or manmade objects that are connected to the internet and process the collected information automatically, with or without human intervention, to gain crucial insights that support more efficient management of limited resources.



Figure-54: IoT based EWS Developed by IIT Mandi
(Source: Parkash and Kathait 2021)



Figure-55: EWS Established by IIT Mandi at Kotrupi Landslide (Source: Parkash and Kathait 2021)

2.2.4.5 Lessons Learnt

1. The slide was reactivated for the third time. The dearth of proper monitoring of the slope led to the mayhem. Therefore, proper monitoring of slobes potential to fail should be monitored appropriately.

2. Though few officials from different departments visited the site no detailed investigation of the slide was done.

3. Rehabilitation issue: As the area falls under the forest department there were issues regarding the settlement of the displaced people.

4. Lack of proper coordination among the line departments was also highlighted.

5. Though the local authority was prompt in response yet they are unaware of the mitigation fund that can be used to mitigate the risks of landslides in the area. Issues of unawareness about mitigation funds and shortage of expertise to prepare DPR at the grassroots level need to be addressed.

6. The early warning system established by the IIT Mandi was vandalised a couple of times. The proper safety of such an important instruments is most importance.

2.2.4.6 References

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5. Central Ground Water Board (2013), Ground Water Information Booklet Mandi District, Himachal Pradesh, Ministry of Water Resources, Government of India.
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8. Parkash Surya (2020): Training Module on Comprehensive Landslides Risk Management. National Institute of Disaster Management, New Delhi - 110002, Pages 282.
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2.2.5 CHAMBA LANDSLIDE

2.2.5.1 Introduction

A cloud burst occurred over the Chamba district on May 3, 2021 and triggered landslides in the area. A local rivulet, Saho-Palyur, overflowed near Kaner village some 20 km from Chamba town (The Tribune May 4, 2021).

2.2.5.2 Impact

The cloudburst prompted a local rivulet, Saho-Palyur, to overflow near Kaner village some 20 km from Chamba town and washed away part of the NH 154A. It led to move a huge pile of debris and drove the river to its right bank, choking it badly. The shifting of the river to its right bank created a situation identical to the one usually found in the middle of a meander.



Figure-56: A car damaged in a landslide in Mehla, Chamba (Source: https://www.tribuneindia.com/news/himachal/cloud-burst-damages-chamba-bharmour-national-highway-triggers-landslides-248142)



Figure 57 Post-landslide view at chamba landslide (Source not traceable)

Water flooded into nearby potato and maize fields as well. Crops had been badly damaged due to cloudburst in the Lihal area under the Bharmour assembly constituency of Chamba. Along with this, a house in the area got damaged due to debris entering the houses of villagers in the villages of the Kuned Panchayat of the area.

In August 1994 also, the Manimahesh cloudburst and a flash flood washed away almost the entire length of Chamba-Bharmour road (62 km), over 50 people were feared dead and 2000 injured. The estimated loss was over 450 crore of Rupees.

2.2.5.3 Actions taken

1. Line departments of the district including the Police department, fire services and Medical Services besides the local community rushed to provide a helping hand in the operation.
2. District administration approached the Army, NDRF, SDRF, Reserve Police forces for the operation. Teams of the NDRF and Indian Army rushed to the spot-on.
3. The whole area was covered with several feet of mud and big boulders. Heavy earth-moving machinery was deployed at the gorge where car lay buried under a heap of debris.
4. The portion of the national highway that had been washed away was restored soon.
5. Relentless rescue and clean-up operations continued for many hours.
6. Compensation were announced for the deceased kin and injured people.
7. The revenue department and administration were also informed about the damage of livestocks to give proper compensation and relief amount to the affected.

2.2.5.4 Recommendations

To protect the Chamba valley from geographical hazards some preventive measures are needed to be introduced therein. These include:

(1) Underground drainage system should be adopted for small channels and streamlets. There should be a small drainage channel on the roadside and water collected from such drainage should be linked with the underground system of drainage to minimize roadside erosion,

(2) Stout embankments should be constructed at the toe of the slopes and on the upper side of the roads,

(3) To protect roads from erosion, high embankments knitted with iron wires should be constructed,

(4) Large-scale deforestation, overlapping and overgrazing should be checked.

(5) Drainages in the uphill slope of the slide area should be channelized and diverted away from the slide area to prevent water percolation. The drainages should be properly maintained.

(6) Precarious boulders above the crest and on the slide should be removed.

2.2.5.5 Lessons Learnt

1. Ensure the departmental resources like equipment, construction material, building resource material, finances etc. used for the emergency purpose are accounted for and recouped as soon as possible.
2. Support recovery and rehabilitation efforts to help communities recover from the disaster impact and build back better.
3. Incorporate lessons learnt into future planning and preparedness actions.
4. Mainstream DRR into new development programs and refer to DRR actions to minimize future risk.
5. Analyze past experiences to know what went well and what could have been done better for risk reduction and emergency response by the department. Document it as lessons learnt annually and after every disaster.
6. Develop a minimum inventory list required for achieving desired performance standards and develop a plan to acquire it over the next few years.
7. Create a mechanism for regular Inspection and maintenance of equipment and acquisition of new equipment as per your minimum inventory list for disaster risk reduction.

2.2.5.6 References

1. Tribune News Service, Dharamsala, May 4 2021 https://www.tribuneindia.com/news/himachal/cloud-burst-damages-chamba-bharmour-national-highway-triggers-landslides-248142
2. Disaster Management Plan - Public Works Department Himachal Pradesh https://hpsdma.nic.in/WriteReadData/LINKS/DMP%20-%20Dept%20of%20Public%20Works%20-%20201848cc26b1-69bb-4165-9e82-a1d113559573.pdf

2.2.6 BOH VILLAGE LANDSLIDE, KANGRA

2.2.6.1 Introduction

The western most district of Kangra in Himachal Pradesh has been an arena of frequent natural catastrophe. The district has witnessed these catastrophes in the form of catastrophic earthquake of 1905 to several damaging landslide and flash flood incidences. Most of the part of district constitutes a fragile geo-environmental condition due to presence of soft to semi consolidated tertiary rock in lower reaches and presence of closely spaced major Himalayan thrusts in upper reaches. The Boh valley in Shahpur Tehsil, Kangra district, Himachal Pradesh is also a part of the same fragile geo-environment. The area is located nearly 50 km from Dharamshala and is approachable by all-weather metal road via Shahpur and Darini villages. The catastrophic landslide occurred at 10.30 hrs (approx.) on July 12, 2021 at Boh village.

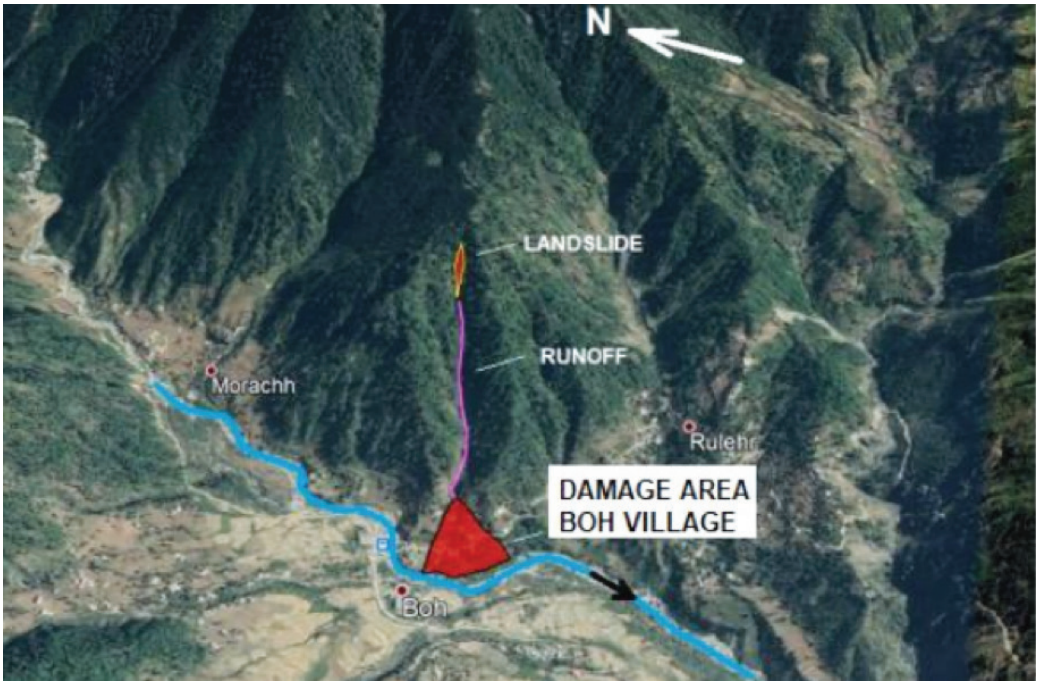


Figure 58 Location of Boh village landslide Kangra district, HP. (Source: Google earth)



Figure-59: The perspective view of landslide runoff and debris flow hit Boh village area (Source: GSI report)

2.2.6.2 Impact

It was raining and water was flowing fast from a nullah on hilltop top overlooking his house. The landslide started slowly. Stones and muck started coming down the hill initially in small quantities. Suddenly a huge landslide started and it gave no time to escape. This resulted in the loss of ten

lives and washing away of seven major houses, other constructions, road and agricultural land. The incidence also made the adjoining areas unstable. The damage was caused by a flash flood charged with debris flow in the upslope incised gully triggered headward landslide due to incessant heavy rainfall during the previous night. A short curve in the nala course at the downstream end possibly facilitated the spread of debris flow over the entire Boh village establishment. Eight houses were completely destroyed in the flash floods and landslides.



Figure-60: The curve at the downstream end of nala course possibly led to spread of debris flow in the Boh village (Source: GSI report)

2.2.6.3 Actions taken

1. Rescue teams reached late in the affected area as the road to village was totally damaged and one had to walk 4 km to reach there.The NDRF team tried to reach the site immediately for relief and rescue operations.
2. About six JCB machines had been deployed to clear the road.
3. The district administration got vacated houses and commercial establishments located on the banks of river Manji.
4. The slum dwellers residing on the banks of river Bagli were also shifted to a government school in the area.
5. Instructions were also been given to people to not go to sensitive places prone to landslides.

6. According to the Meteorological Department forecast, heavy rain on July 13 as well as from July 14 to 16 was predicted. Keeping this in mind, orders were issued under the Disaster Management Act 2005 to district officers of all the departments in Kangra district to remain alert.
7. Affected people were given compensation as per government norms.

2.2.6.4 Recommendations

1. Prohibition of flow barriers all along upstream nala course at suitable distances
2. Provision of concrete lined spacious nala course with a provision of culvert on the road ensuring the easy passage of debris flow.
3. Concrete retaining structure all along the road stretch terrace/debris cone material with adequate drainage holes
4. Launch of landslide safety (vulnerability identification) programs in villages/habitat located in such fragile Geo-environmental area
5. Conducting regular contact programs for public awareness of landslide and related incidences in particular during pre-monsoon.
6. Settlement/construction for dwelling may be avoided along nala/khad/river banks or flood plain area and along the nala banks and dormant courses.
7. Suitable plantation/afforestation for the stabilization of nala banks and disturbed ground
8. Implementation of safe and scientific methods of slope modification and stabilization.
9. Identification of stable ground for safe construction and urbanization with proper drainage outlets and protection wall.

2.2.6.5 Lessons Learnt

1. About a five to six hours delay in the arrival of rescue teams could have cost loss of life for many people trapped under debris. Therefore, the emphasis should be laid on the training of the first responders i.e. the people themselves.
2. The gushing water from the drain damaged vehicles of some tourists parked in the streets. The natural drain that was more than 20 feet wide had been narrowed to less than 10 feet at places due to encroachments by some hoteliers.
3. The narrowing of the drain led to water gushing on to streets and damage to vehicles.
4. The encroachments on river beds were the primary cause of loss to property.

2.2.6.6 References

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2. Manoj Kumar and Pradap Jagan R, Geological Survey of India, Chandigarh Note On Preliminary StudiesofBoh Village Landslide, Tehsil Shahpur, District Kangra, Himachal Pradesh. https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=3475

2.2.7 BATSERI VILLAGE, KINNAUR

2.2.7.1 Introduction

A massive rock fall incidence occurred on the opposite bank of Batseri village, on Sangla-Chitkul road, district Kinnaur, Himachal Pradesh, around 13:10 hrs on 25 July 2021.

2.2.7.2 Impact

1. The landslides, triggered by rainfall, collapsed a bridge and damaged vehicles on the Batseri-Sangla road.
2. Around 100-120 people, including tourists and locals, were stranded at the site of the incident.
3. Several orchards, vehicles and houses were damaged in the incident.



Figure-61: A bridge collapsed due to a landslide at Batseri of Sangla valley in Kinnaur District . (ANI Photo)



Figure-62: Rockslide in Kinnaur, Himachal Pradesh | Screengrab/Twitter

2.2.7.3 Actions Taken

1. The district administration was put on high alert after heavy rain warning.
2. Police Home Guards and ITBP personnel reached the site for rescue operations. The QRT team of Sangla Police got engaged in extracting the dead bodies.
3. Prime Minister Narendra Modi announced an ex-gratia of Rs 2 lakh each from PMNRF to the next of kin of those who lost their lives in the incident and Rs 50,000 to the injured.
4. Chief Minister Jairam Thakur also announced an ex-gratia of Rs 4 lakh each to kin of those who lost their lives in the accident and government treatment of the injured.

2.2.7.4 Recommendations

The various recommendations deduced are as per below-

1. Removal of precariously disposed rock mass/ boulder from the source/trajectory area.
2. The application of wire mesh rock bolt etc. in the vulnerable part of escarpment/ source area.

3. Near immediate vicinity of foot slope of the escarpment, provision of suitable catch ditch and catch fence.
4. Upslope loose boulders stabilization by using draping wire mesh and crate wall cum catcher ditch at different level along the debris trajectory.
5. Suitable afforestation/ plantation/ biotechnical stabilisation of the slope material, in particular in the trajectory area.
6. Concrete/ masonry retaining structure all along the road stretch cut in terrace/debris cone material with adequate drainage holes.
7. Provision of rock fall shelter in risky stretch of the road. Rock deflector to protect important infrastructure such as bridge etc.
8. During rainy season, the traffic movements under strict onsite and offsite slope monitoring.
9. Installation of sign boards/ banners at appropriately identified vulnerable locations for cautioning to the commuters.
10. Widespread advance communication/warning to the dwellers/visitors regarding heavy rainfall etc.
11. Widespread Landslide Awareness Program in landslide vulnerable areas.

2.2.7.5 Lessons Learnt

1. The video of the incident illustrates that a mass collapsed, maybe about 700 m vertically above the bridge and fragmented to generate the “evil dancing boulders”. The track record of past research studies reveals that the situation in which the boulders start to rotate about a short axis and to bounce is very dangerous. This is the case for numerous boulders here, generating extremely high velocities. Before the bridge is hit one boulder (visible at about 19 seconds into the final video above) takes an enormous bounce due to the terrain. So this means analysis of past case histories can lead to the development of effective mitigation measures.
2. Proper guidelines should be given to the tourists as they become the first responders.
3. As evident from the footage, locals who were recording the rockslides raised an alarm after the boulders started coming down from the top of the mountain, so dissemination of information can not only save lives to a great extent but also leads to documentations of perishable data.

2.2.7.6 References

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2.2.8 KALI DHANK LANDSLIDE, DISTRICT SIRMAUR

2.2.8.1 Introduction

In morning hours of July 30, 2021, a huge debris slide occurred at Kali Dhank near Barwas village on NH-707 (Paonta Sahib-Hatkoti road), Sub Division Shillai, Tehsil Paonta Sahib, District Sirmaur, Himachal Pradesh. The slide zone is located at a distance of about 29km from Paonta Sahib via Sataun. Heavy rainfall was reported in the affected area on previous two days.



Figure-63: A damaged stretch of road near Kali Dhank (Source : The Tribune 30 July 2021)

2.2.8.2 Impact

1. Commuters had a narrow escape when two stretches of the National Highway-707 caved near Kali Dhank and Kacchi Dhank in Paonta Sahib, Sirmaur, following downpour in the area for the last 48 hours. The highway was closed to vehicular traffic after the massive landslides.
2. Several vehicles had stopped just few metres away from the affected spot in Kali Dhank, where the road caved in first along the valley side followed by crumbling of the hill, taking water pipes and electricity poles along.
3. In a video which went viral, a group of villagers present near the spot ran helter-skelter as the hill started crumbling. They also warned motorists to stay away from the site.

2.2.8.3 Actions Taken

1. Commuters going from Paonta Sahib to Shillai were directed to follow Puruwala- Kilod- Jong- Kafota- Shillai route.
2. Policemen were posted at the entry of these roads from Paonta Sahib, Shillae, Rajban, Sataun etc. to inform commuters about alternate routes informed DSP Paonta Sahib Bir Bahadur. Sub-Divisional Magistrate, Paonta Sahib, Vivek Mahajan visited the spot while the road-widening project director and staff of the revenue and electricity department assessed the damage.
3. Sirmaur DC, instructed the police to erect barricades before the affected site to avert any untoward incident.

2.2.8.4 Recommendations

1. Excavation work had also been carried out in the valley area for limestone mining two years ago. This might have triggered the mishap. The loosened earth material on the hill above the road gave way after its base caved in.
2. The 150m stretches of NH-707 constructed over debris material washed away. The restoration of the same has been suggested by realigning the NH-707, partly by hill mass cutting and partly by filling in order to restore emergency services and socioeconomic activities in the area. The road alignment may be achieved in the competent rock strata in order to avoid slope instability.
3. In view of frequent exposure of bedrock in the slide zone, further widening of the road may be exercised by way of muck/ debris filling using the bedrock as hold fast and with adequate toe support.
4. The benching in uphill debris mass as well as in rock mass, may be carried out very carefully, scientifically along with their simultaneous effective stabilization.
5. The up-slope hill mass and village establishments must be put to frequent observations with regards to any ground signature of instability such as developments of tension crack, joint openings/ widening, land sinking, development of crack in building, the collapse of soil along slope or Nala, tilting of trees, sudden appearance or disappearance of a surface stream or reduction in water volume etc.

6. Altering the geometry of the steep slope by flattening and benching along with draining out any ingressing Nala or rainwater.
7. Use of soil nailing, grouting, wire mesh draping, biotechnical slope stabilization measures (plantation of suitable trees with deep-rooted species, application of geo-jute/ geo-mats etc) in the slope debris mass of the uphill and downhill (road/ dump filling).
8. Provision of check dams along runout path.
9. The breast and retaining structures along the road must be provided with adequate filter and drainage, in particular, when constructed in debris filled mass.
10. Installation of sign boards/ banners at appropriately identified vulnerable locations for cautioning to the commuters.

2.2.8.5 Lessons Learnt

The landslide is natural as well as geogenic in nature, in view of presence of fractured bed rock, incohesive slope debris resting over the steep slope that may have weakened in due course of quarry activities near its toe, now abandoned and finally failed up on slope saturation by heavy rainfall.

1. Widespread advance communication/warning to the dwellers/visitors regarding heavy rainfall etc.
2. Widespread Landslide Awareness Program in landslide vulnerable areas.
3. Incorporate lessons learnt into future planning and preparedness actions.
4. Mainstream DRR into new development programs and refer to DRR actions to minimize future risk.

2.2.8.6 References

1. Manoj Kumar, Pradap Jagan R and Abhinav Poonia, Geological Survey of India Note On Preliminary Geological Studies of Kali Dhank Landslide Near Barwas Village On Nh-707 (Paonta Sahib- Hatkoti Road) Sub Division Shillai, District Sirmaur, Himachal Pradesh.

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2.2.9 NIGULSARI VILLAGE ROCKSLIDE

2.2.9.1 Introduction

On August 11, 2021, around noon, a rock slide incidence took place along NH-05 near Nigulsari village

in Tehsil Nichar of District Kinnaur, Himachal Pradesh. The above rock slope failure incidence brought down appreciable volume of large rock blocks of foliated gneiss rock mass comprising rock blocks of varying dimensions and soil mostly with relatively coarser fraction. As per the reconnaissance report published by GSI 2021, the failure appeared to be a natural rock slope failure with no signatures of anthropogenic activity seen in or adjoining areas of the crown, from where the failure was initiated as per the field observation.



Figure-64: Landslide at the Reckong Peo-Shimla Highway in Kinnaur district in Himachal Pradesh (Source: https://www.hindustantimes.com/india-news/major-landslide-in-himachal-s-kinnaur-more-than-40-feared-buried-101628669153501.html)

2.2.9.2 Impact

As per media reports, the slide debris engulfed one HRTC Bus with reportedly 30 passengers onboard. The bus was feared to have rolled several feet down the gorge towards the Sutlej river. The bus was on its way from Reckong Peo in Kinnaur to Haridwar in Uttarakhand. Moreover, at least 4-5 smaller four wheelers and a few cattle have also been engulfed in debris causing loss to life and property. Furthermore, damage to highway and valley side metallic girders/railing have also been caused by the above incidence.



Figure-65: Vehicles buried under the debris
(Source: https://www.india.com/news/india/himachal-kinnaur-landslide-over-40-feared-buried-under-debris-army-ndrf-rescue-operation-underway-4881038/)



Figure-66: Debris engulfed passengers onboard in bus
(Source: https://www.india.com/news/india/himachal-kinnaur-landslide-over-40-feared-buried-under-debris-army-ndrf-rescue-operation-underway-4881038/))



Figure-67: National Disaster Response Force (NDRF) team during a rescue operation at the site of a landslide in Kinnaur district, (Source: India Today)

2.2.9.3 Actions taken

1. Teams from the Army, the National Disaster Response Force, the Indo-Tibetan Border Police, the Central Industrial Security Force, police and district administration, reached the incident site for rescue operations.
2. Unmanned Aerial Vehicle (UAV) was used at the affected site to monitor the situation. Drone images showed that debris was around 10-15 feet high and spread across 50-100 meters. And hence the rescue operation took some time.
3. Arrangements have been made for providing medical treatment to the injured and the district administration had been directed to provide all possible help to the injured.
4. The rescue operation at the site of the landslide in Nigulsari, Nichar Tehsil of the Kinnaur district, was suspended at 9 pm on 11/8/21 due to dark conditions and shooting stones, which made the rescue operation difficult. The rescue operation resumed on 12/8/21 morning.
5. At the spot 10 ambulances and 4 earth movers were deployed
6. Ex-gratia of Rs 2 lakh was announced for the kin of the deceased and Rs 50 thousand for the injured.
7. Rs. 1 lakh will be given to the kin of the dead bus passengers by the Transport Department, in addition free treatment was provided to the injured.
8. The state government asked the experts to conduct a geological survey of the area.

2.2.9.4 Recommendations

On the basis of the reconnaissance, GSI officials suggested following measures that can be useful in minimizing the slope failure incidences and risk to commuters. These suggestions need to be converted into actionable points only after adequate investigations, wherever necessary.

1. Vigil along the slope failure affected stretch as well as nearby vulnerable stretches and slope failure/landslide locations along NH-05 irrespective of whether or not the preventive measures are in place: This may help in early detection of likely failure and measures such as the closure of lanes likely to be affected for the specific time etc. can be implemented.

2. Identification and removal of rock blocks that are insecurely positioned and are likely to fall on the road alignment: As far as possible, blasting should be avoided for carrying out the removal of such blocks. This includes a vulnerable block ready to fall above the crown

3. Contour parallel drains: At least two to three contour parallel drains all withalong the crown at appropriately identified levels to diver the surface water towards nalas on either side.

4. Immediate filling of tension cracks: with suitable impervious material.

5. Protective measures for cut slope: Possibility double-layered shotcrete or wire mesh can be explored for the cut slope section as several loose rock blocks are appearing that may fall at any point of time, especially during the course of incessant or perennial rainfall spells. Detailed studies, however, may pl. be carried out for the same.

6. The slope preparedness is along-termm process and such susceptible slopes can be identified with a fair degree of confidence through the process of landslide susceptibility/zonation on different scales.

2.2.9.5 Lessons Learnt

1. There appear to be no preventive measures in place that are capable of reducing uncontrolled flow of water over the moderately to steeply inclined slope/valley facing joint planes, above the cut slope section.

2. While climate change (another anthropogenic factor) leading to more frequent events of high intensity rainfall is worsening the landslide potential of the area, what we are doing in the name of developments is multiplying the disaster potential several fold.

3. A study carried out in Kinnaur between 2012 and 2016 found that a push for hydropower projects in the name of clean energy brought rapid land-use changes that adversely impacting local terrestrial ecosystems and communities inhabiting them.

4. Landslides have been a way of life in Himachal, but the level of human exposure to risk of disaster had remained low due to the state's low population density. However, due to a big push for construction of infrastructure and roads and the resultant increase in human settlements and road traffic, more lives are in danger than ever before, especially during rains.

2.2.9.6 References

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3. https://zeenews.india.com/india/himachal-pradesh-landslide-death-toll-reaches-10-14-rescued-in-kinnaur-2384000.html
4. https://himachalwatcher.com/2021/08/12/kinnaur-tragedy-10-bodies-recovered-still-no-trace-of-hrtc-bus-50-60-persons-feared-to-be-missing/
5. https://www.pressreader.com/india/the-hindu/20210812/281509344249411

2.2.10 GHANDAL LANDSLIDE

2.2.10.1 Introduction

A massive landslide near Judicial Academy Ghandal on 13 Sept 2021 night blocked the National Highway 205 that connected Shimla to Mandi.



Figure-68: Landslide near Judicial Academy Ghandal (Source: Shimla DDMA)

2.2.10.2 Impact

1. Landslide swept away stretch of road near National Law University, at Ghandal, 20km from Shimla.
2. Landslide caused 50 metres of the road to cave in.
3. Five persons who were travelling in the car managed to escape



Figure-69: People trying to pull a car that fell down due to a landslide amid heavy rainfall in Shimla, (Source: ANI Photo)

2.2.10.3 Actions Taken

1. The district administration diverted the traffic through the Nalhatti-Kalhatti link road. Nalhatti is around 5km from Ghandal and Kalhatti is around 4km from Nalhatti. The heavy flow of traffic on this link road also caused trouble for local commuters as a jam-like situation was witnessed there.
2. NHAI officials were asked to repair the road at the earliest.
3. The public works department removed the bottlenecks from the alternate route.

2.2.10.4 Recommendations

1. No proposed widening of highway stretches in the state should be allowed till slope studies and stability analysis, of both the hill and valley side of the national highway, are undertaken.
2. Road developers also need to determine the effect of anthropogenic (human) activities on the roads.
3. The graded atlas based on the potential human and asset loss/damage vis a vis traffic intensity, importance of connectivity (could) be prepared and the priority-based remedial plan to rectify all locations may be drawn up.

2.2.10.5 Lessons Learnt

1. Due to the lack of the proper drainage system, rainwater flowed on the road and caused landslides.
2. As per residents (according to media reports) cracks were visible on the road 3 months back but NHAI and PWD ignored the fact.
3. The immediate measures include installing cautionary signs in the vicinity of potential landslide locations and round-the-clock vigil to forewarn commuters of any imminent landslide hazard at active landslide locations.

2.2.10.6 References

1. https://timesofindia.indiatimes.com/city/shimla/portion-of-shimla-ghagas-highway-collapses-in-landslide/articleshow/86218638.cms
2. https://www.tribuneindia.com/news/himachal/massive-landslide-causes-section-of-nh-205-connecting-shimla-to-mandi-to-cave-in-311022
3. https://theprint.in/india/governance/road-audit-monitoring-at-risk-points-vital-say-experts-as-landslides-batter-himachal-highways/726612/

2.2.11 MULTI-STOREY BUILDING COLLAPSES, SHIMLA

2.2.11.1 Introduction

On 30th September 2021 an eight-storey building collapsed like a deck of cards within a few seconds and also turned two more buildings located below it into rubble. Videos of this building collapse went viral on social media and were also picked up by national media.

The scene created panic among onlookers, especially the people residing in the nearby buildings. A hotel – Hari Palace-located right behind the building is also at risk now.



Figure-70: Building collapse (Source: https://himachalwatcher.com/2021/10/01/building-collapses-in-shimla/)

2.2.11.2 Impact

No loss of life was reported.

According to the State Disaster Management Authority, the eight-storey building at Ghoda Chowki near Hali Palace in Shimla the named Darshan Cottage, belonged to Gurmeet Singh – a local businessman. One of the two other buildings which were damaged was known as Nirmala Bhatt and Narayan Cottage. Both buildings were two-storied. The HPSDMA said the loss was estimated to be around Rs 6 crores. While the building crumbled within seconds, its foundation had started to give way a couple of days back. The house had also developed cracks about a week ago and therefore, it was already evacuated. No person was present inside the building when it collapsed.



Figure 71 Left over debris of collapsed building in shimla ((Source: https://www.tribuneindia.com/news/himachal/multi-storey-building-collapses-in-shimla-no-loss-of-life-318316).

2.2.11.3 Actions Taken

1. At the time of the collapse, the Deputy Commissioner, Shimla, Aditya Negi and Deputy Mayor, Shailender Chauhan, were also present at the spot along with a team of fire services.
2. The buildings below it were also evacuated as a precautionary measure. Reports said that the hotel owner was also asked to evacuate the building, but he had refused to do so.
3. The affected persons were given an immediate relief of Rs. 10,000, the district administration informed.

4. Temporary alternate arrangements were made to provide shelter to these families which were rendered homeless. The eight-storey building at Ghoda Chowki near Hali Palace in Shimla.

2.2.11.4 Recommendations

The Himachal Government constituted a fact-finding committee to look into the reasons for the collapse of building in the Kachi Ghatti area of the town besides making recommendations to prevent recurrence of such mishaps.

1. The foundation of collapsed building in Kacha Ghatti area being weakened due to seepage of water. The collapse has posed a threat to the adjoining buildings some of which have developed cracks. Kachi Ghatti as the name suggests has come up on loose strata of debris dumped during construction activity in the main town. The area is right at the entrance to the town after Sankat Mochan temple and several high-rise buildings have come up here despite the area not being suitable for such heavy structures.

2. **Regulations of prescribed limits for development activities are exempted under section 30-a of the Himachal Pradesh town and country planning act, 1977 (Act no. 12 of 1977).**

1. Residential Buildings and Farm Houses

(i) Maximum floor area = 600.00 m^2

(ii) Maximum number of storeys = 3 nos. +1 parking floor wherever feasible.

(Note: The applicant may have a maximum floor area of 600.00 m^2 distributed over not more than three storeys.)

2. Commercial Use

(i) Maximum floor area = 100.00 m^2

(ii) Maximum number of storeys = 2 nos.

(iii) Minimum access = 3.00 m

(iv) Parking = For loading, un-loading and parking purpose suitable community parking space has to be arranged by the shop owners.

(Note: The applicant may have a maximum floor area of 100.00 m^2 distributed over not more than two stories.)

3. The eight-storeyed building had been granted approval by the Special Area Development Authority (SADA) in 2003 and this area of Kachi Ghattiu along with other parts was merged into Shimla MC in 2006. “On bare perusal of the record, permission was granted by SADA for a six-storied structure.” So construction practices need to be carried out as per town planning norms in the vulnerable and hazard-prone areas else such practice will lead to loss of life and infrastructure in the future also.

4. Out of the over 25,000 unauthorised constructions in the state, awaiting regularisation, most are located in Shimla (Urban), Shimla (Rural) and Kasumpti assembly segments which constitute the Shimla Planning Area. The fact that the state capital, the summer capital of British India, is still expanding on the basis of the 1979 Interim Development Plan (IDP) speaks volumes of the scant regard being paid towards regulated and planned growth.

5. The incident has exposed the haphazard construction activity, though majorly curbed by the National Green Tribunal order, banning all new construction in the Core and Green Zone and restricting new buildings in other parts to merely two-and-a half storeys.



Figure-72: A man stands near the collapsed building at Kachi Ghati in Shimla. (Source: Tribune photo: Amit Kanwar)

2.2.11.5 Lessons Learnt

1. The collapse of a seven-storey building in Kachi Ghati here has failed to push law-enforcing agencies to enforce building norms to avoid such a disaster in future.
2. There are widespread violations in most multi-storey buildings in the Kachi Ghati-Ghora Chowki area at the entrance to the capital from the Tara Devi side. Most buildings, precariously located on steep slopes, have illegally raised additional floors and their owners are using the basements for residential or commercial purposes, which are meant to be non-habitable.
3. Constructions continue even as landslides are taking place in some portions. The constructions on nullahs or "bawris" to pave the way for multi-story structures result in seepage which can make the foundation weak.
4. Locals residing in the area revealed that most residential buildings had been converted into hotels. "To meet the enhanced space requirement, most hotel owners have dug up basements while others have put the closed basement to use". Others have started bread and breakfast and homestay units as hospitality was emerging as a profitable venture.
5. The Tourism Department to seems to have turned a blind eye and failed to check whether hotels, guest house and bed and breakfast units have obtained permissions.
6. The NGT's suggestion of restricting the construction on slopes in soft and rocky areas to 35 degrees and 45 degrees for areas with hard subsurface too is not being enforced.
7. Many commercial ventures are operating on domestic water and electricity connections that point to the lackadaisical approach of the government in dealing with violations.

8. Only one building collapsed but the manner in which multi-story structures have been.- raised in this area, in violation of all norms, more such disasters cannot be ruled out. The Kachi Ghati area, being unstable and with loose soil, is not suitable to take the load of heavy structures.

2.2.11.6 References

1. https://www.tribuneindia.com/news/himachal/shimla-building-collapse-no-steps-taken-to-enforce-guidelines-321307
2. https://zeenews.india.com/india/multi-storey-building-collapses-in-shimla-due-to-landslide-horrific-visuals-go-viral-2398687.html
3. https://www.indiatvnews.com/news/india/himachal-pradesh-landslide-national-highway-5-blocked-shimla-landslide-746307
4. https://www.tribuneindia.com/news/himachal/expert-report-on-shimla-building-collapse-this-week-338261

2.3 WEST BENGAL

West Bengal is no exception as far as sufferings caused by extreme events are concerned. Different parts of West Bengal are vulnerable to the natural calamities like Flood, Cyclonic Storms, Earthquake, Landslide, Drought and Embankment Erosion. Among these events the archival documentation of landslides is discussed in the subsequent section.

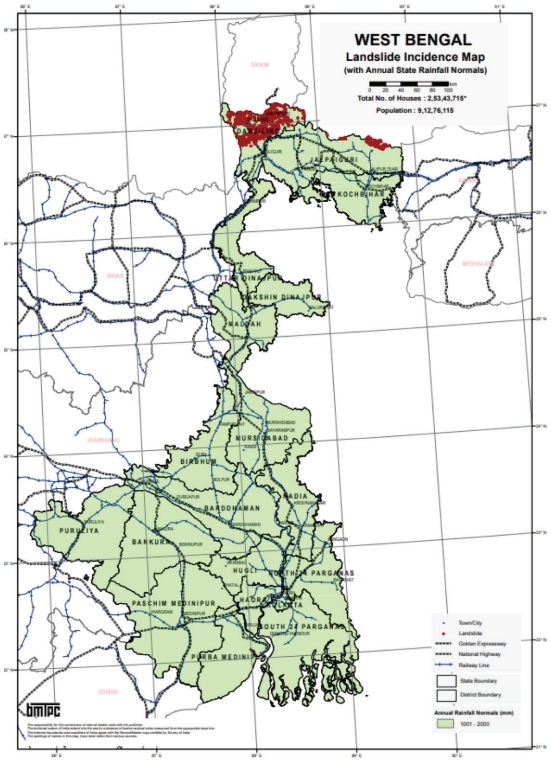


Figure-73: Landslide Incidence Map of West Bengal (Source: BMTPC, 3rd Edition)

The landslide hazard in West Bengal has been observed mostly in the hilly terrains of Darjeeling District. Urbanization, especially in the hilly terrains, involving construction activities often causes perturbations in the hill slopes triggering landslides.

TABLE 9: HISTORICAL RECORDS OF LANDSLIDES IN WEST BENGAL (SOURCE: WEST BENGAL STATE DISASTER MANAGEMENT PLAN 2015-16)

Year	Area	District	Block (S)/ Municipality	Damages
1998	Lodhoma		Darjeeling-Palbazar	Population affected: 40000; Death : 21 Houses damaged 3,498.
	Lalbadh Kolbong (Simbong Division)		Rangli Rangliot	
	All GP expert Gayabari and Sukna		Kurseong	
1999	Samalbong		Darjeeling-Palbazar	Population affected: 321; Death: 13 Houses damaged: 1,697.
	Sittrong 1 & 3, Tindhoria		Kurseong	
2000	Halhalay		Darjeeling-Palbazar	50 houses damaged. No Casualty.
	Goetheis & Sepoydhura		Kurseong	
	Tista Valley, Poomung, Lamhatta		Rangli Rangliot	Population affected: 72; Death: 07, Houses damaged: 05.
2002	Samdong 2		Kalimpong II	
	Daragaon, Gayabari I		Kurseong	
2003	Dabaipani, Jinglam		Rangli Rangliot	Population affected: 72; Death: 07, Houses damaged: 05.
	Sakhibhir		Kalimpong II	
2004	Maneydara, Labdaah	Darjeeling	Rangli Rangliot	Population affected: 103417; Death: 25, Houses damaged: 5499.
2006	Bloonfield		Darjeeling-Palbazar	Population affected: 3029; Death: 13, Houses damaged: 2375.
	Gairigoan, Sindepong		Kalimpong I	
	Mangalpuri, Nalban		Darjeeling-Palbazar	78 Houses damaged.
	Margaret's hop, Beach Gaon		Jorebunglow-Sukiapokhri	Houses were damaged.
	Singringram, Rangli		Rangli Rangliot	Houses were damaged.
2007	Upper Khani Mangal Basti, Lamini		Kalimpong	5 persons died. Few houses were fully damaged.

	Bindu, Patengodak, Panjabi Golai, Shermali		Gorubathan	46 houses were partly damaged and 109 houses were fully damaged.
	Bagogra, Kharay, Bhotey busty, Mirik-Karshiong Municipal areas		Kurseong	3 persons died. 67 houses were damaged.
2008	5 Blocks and 1 municiplaities are affected		Sukhiapokria, Kalimpong-I Matigara, Khoribari, Phansidewa Blocks and Kalimpong Municipality	Population affected: 16,674; Death: 03, Houses damaged: 3173.
2009	AILA coupied with landslide occurred in 555 villages in 8 blocks and 4 Municipalities	Darjeeling	Bijanbari, Jorebunglow Sukhiapokhuri, Takdah, Kurseong, Mirik, Kurseong, Mirik, Kalimpong – I & II, Gorubathan Block and Darjeeling, Kurseong, Mirik, Kalimpong Municipalities	Population affected: 1,45,758; Death: 41, Houses damaged: 26595.
2010	Kurseong		Kurseong Block	1 k.M stretch of NH 55 swept away by the landslide.
	Kalimpong		Kalimpong Municipalities	3 Persons died and houses were damaged.
2011	Tindharia		Kurseong Block	NH 55 and Railway track was damaged.
2012	Ten Blocks and One Municipalities.		Kalimpong I, Kalimpong II, Gorubathan, Jorebunglow-Sukhiapokhuri, Mirik, Kurseong, Naxalbari, Phansideoa, Khoribari, Bijanbari.	Houses were damaged.

Apart from these, a few significant landslides also occurred in West Bengal prior to 1998 and after 2012. Some of them are discussed below based on the a available literature/research paper/archival records:

2.3.1 AMBOOTIA LANDSLIDE

2.3.1.1 Introduction

Ambootia or Ambootay is a tea estate village in Darjeeling district in the state of West Bengal in India. On October 2-5, 1968, numerous earth flows, debris flows and larger landslides were formed during extreme rainfall in the Darjeeling Himalaya (Starkel 1972). The Ambootia landslide developed at the southern edge of the Ambootia TE on the left side of the Balasan River Valley, dissecting the W-E marginal ridge rising 1200-1800 m above sea level. The researchers observed Ambootia (Froehlich et al. 1991, 1992) as a "landslide valley" because it not only has shaped the valley but its evolution is also the product of gravitational slope processes acting in conjunction with linear down cutting. Prior to the 1968 landslide the steep lower part of the valley side was covered with forest (jungle) changing into shrubby jungle with bamboo (degraded jungle) upslope. The gentle slope above was occupied by tea plantations towards the north and two villages — Taar Gaon and Darah Gaon — closer to the landslide area in the south. The two villages had 174 and 126 homes, respectively. The incessant and torrential downpours of 3 to 5^{t} October 1968, left behind a legacy and a landmark in the Balason basin, a gaping scar in the form of the Ambootia landslide, one of the biggest in the county. Located on the left side of the Balason river, only 4.5 km from the Himalayan margin, the landslide was initially only a shallow khola (channel), along the southern margin of the Ambootia tea garden, very close to Karsiyang town. The landslide itself starts about 200 m below the ridge, rising 1350 m a.s.l. and runs 625 m down the Balason valley. The specific feature of this landslide valley is its form and close co-operation of gravitational processes and linear down cutting, which are continuously active, in contrast to other stabilized smaller landslides (Froehlich, Staricel, Kasza 1992). According to Froehlich & Starkel (1992), the Ambootia landslide valley has a very complex character and shape.



Figure-74: Ambootia landslide — northern scarp.
View from the opposite side of the Balasan River valley (July, 1984) (Source: Starkel 2010)

2.3.1.2 Impact

Decades of conventional tea growing in Darjeeling, which often included the hefty use of pesticides and herbicides, left soils particularly on steep slopes bare and degraded. Add to that the rainstorms of the monsoon season there is a disaster waiting to happen ad in1968 it did happen In a huge landslide on the Ambootia tea estate t**wo whole villages disappeared into the abyss, it 809 was sheer luck that nobody was killed.**



Figure-75: Upper retreating part of landslide and extensive colluvium fan, undermined by niches (Source: Starkel 2010)



Figure-76: Western active part of right slope with rock falls and chutes (Source: Starkel 2010)

2.3.1.3 Actions taken

Laborers on Ambootia and other plantations lived in villages situated sometimes above, but more regularly, below tea fields. On plantations, edges of all kinds mattered. When the rows of planted tea began to lose their linear, contoured structure when they began to dip and sag workers saw a signal of impending danger. Underneath the hard, gnarled bushes that workers cling to as they pull their way across shear slopes of tea was something dangerously soft. The demands of labor and agricultural intensification made landslides either already-existing ones or potential new ones a matter of considerable concern. Workers traveled from villages to different parts of plantations each day to pluck tea. During the monsoon, those who lived farther "down" in valleys risked both contributing to landslides as they trudged through the fields (roads and footpaths are a common landslide origin point) and being victims of them when they returned home. For tea pluckers, the threat of landslides spoke to the impending loss of Gorka land. Even land itself went down the mountain, but never came back up. Claiming land, preserving it, in both meta-political and material senses, was key not only to a more stable future for future generations of Gorkhas, but a future in which accountability might be measured.

2.3.1.4 Recommendations

1. On plantations, forests serve not only as property markers, but also as ecological barriers, providing crucial protection during the yearly monsoons for the tea bushes and people who reside around them.
2. Forests should also be kept thick in places where it is "too steep to plant," such as the location of the Ambootia landslide.
3. Scientific accounts of the Ambootia landslide, however, present an "apolitical" version of its history, noting both that the Himalayas are "very young" mountains that have difficulty "maintaining equilibrium" and that deforestation and road construction play a role (Froehlich et al. 1992; Froelich and Starkel 1987; Starkel 2010, 1972; Starkel and Basu 2000; Starkel and Sarkar 2014).

2.3.1.5 Lessons Learnt

Ambootia landslide valley has reached a stage of maturity and stabilization over the last few years. This is primarily the result of revegetation and the development of anti-erosion measures across the valley floor. Only a number of steep rocky parts are still exposed to small rock falls, slumps and slides. Localized earth flows may become accidentally triggered on the vertical walls of niches formed in colluvium deposits and debris flows in the main river channel during episodes of high intensity rainfall.

It cannot be ruled out that after decades of bedrock weathering by continuous rainfall since the 1968 landslide, the upper niche of the landslide valley may retreat again or the main gully may become dissected again by robust debris flow.

In the Darjeeling Himalaya, there exists many deep and wide valleys segmenting mountain slopes. Such valleys probably formed in a manner similar to that of the Ambootia landslide valley via the combined long-term effects of gravitational processes and linear erosion. Long-term observations carried out in the Ambootia landslide valley have shown that the stabilization of a large landslide is a gradual process and requires several decades of time in order for this type of process to reach completion.

2.3.1.6 References

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2. https://en.wikipedia.org/wiki/Ambootia

2.3.2 DARJEELING LANDSLIDES

2.3.2.1 Introduction

A series of landslides were caused by heavy rain in the three sub-divisions of Darjeeling district on on June 30, 2015 Landslip occurred near Kalijhora. Another landslip occurred in Darjeeling district even as people are returning home from relief camps where they had taken shelter following landslides since July 1,2015.



Figure-77: Bystanders looking at a damaged bridge in Garidhura village, some 35 km from Siliguri, on July 1, 2015 (Source: The Tribune, July 1st 2015)



Figure-78: Rescue workers search for survivors in Darjeeling district on July 1, 2015. (Source: The Tribune, July 1st 2015)

2.3.2.2 Impact

1. At least 40 lives were lost in the landslides that hit Darjeeling Hills on June 30 late at night.
2. 21 persons died in Mirik alone, while 13 others were reportedly missing. The remaining died in Kalimpong-1 and 2, Lava, Sukhia block and Gorubathan.
3. Twenty persons were also injured in the calamity and 15 people were reported missing at 8 Mile and 11 Mile areas in Kalimpong.
4. More than 100 people were reportedly stranded at different places in the district.
5. The landslides at 25 places in Darjeeling, Kalimpong and Kurseong sub-divisions also caused extensive damage to NH-10 and NH-55, cutting road link to the region. NH 10 bore the brunt with the road link to Kalimpong, Lava, Lolegaon and Garubathan snapped. NH 55 connecting Siliguri, Matigara with Darjeeling was also damaged mostly in Mirik and Rohini areas.
6. A bridge on NH 55 has been washed away at Nimbujhora, the officials said.
7. Many places in Siliguri, Jalpaiguri and Dooars were reportedly flooded.
8. Landslides occurred at several places between Mongpong and Sevoke Kalibari, leaving people stranded on NH 31 which links these places.
9. Around 400 houses were either damaged or destroyed in the disaster.

2.3.2.3 Actions Taken

1. Two NDRF teams, comprising nearly 100 personnel, reached the affected areas for rescue and relief operations and the Army's help was also sought.
2. The relief camps in the tingling area of Mirik made in which 600 people stayed.
3. Apart from Tingling Primary School, relief camps have been set up at the garden's hospital, creche, tea garden office, assistant manager's bungalow and also at Soureni Community Hall where the homeless, all locals, were housed.
4. 49 relief camps were made where around 3,200 people stayed.
5. Locals recovered the bodies and rescued the injured, put them in hurriedly made bamboo stretchers and carried them to the nearby health centres.
6. In the aftermath of the Darjeeling landslides, two teams of GSI experts surveyed two worst-affected zones of Mirik and Kalimpong.
7. The GSI team ascertained the category of landslides, the dimension of the landslide, the geology, the geomorphology (study of characteristics, origin and development of landforms) as well as what triggered them.



Figure-79: Villagers trying to clean out the entry road which was badly damaged due to landslide at Limbudora village at Tingling tea estate in Darjeeling district near Mirik on July 3rd, 2015. (Source: https://economictimes.indiatimes.com/nation-world/heavy-rains-trigger-landslides-in-west-bengal/villagers-try-to-clean-roads/slideshow/47935629.cms)



Figure-80: People looking at a damaged road in the landslide-hit area of Mirik near Siliguri (Source: https://economictimes.indiatimes.com/nation-world/heavy-rains-trigger-landslides-in-west-bengal/villagers-try-to-clean-roads/slideshow/47935629.cms)



Figure-81: A bridge collapses due to heavy rains in Darjeeling on July 1, 2015.
(Source: https://economictimes.indiatimes.com/nation-world/heavy-rains-trigger-landslides-in-west-bengal/villagers-try-to-clean-roads/slideshow/47935629.cms)



Figure-82: SSB jawans dig out the debris amidst bad weather at Limbudora village at Tingling tea estate in Darjeeling district near Mirik on July 3, 2015
(Source: https://economictimes.indiatimes.com/nation-world/heavy-rains-trigger-landslides-in-west-bengal/villagers-try-to-clean-roads/slideshow/47935629.cms)

2.3.2.4 Recommendations

1. Areas covered by degraded natural vegetation on upper slopes are to be afforested with suitable species. Existing patches of natural vegetation (forest and natural grassland) in good condition, should be preserved.

2. Any developmental activity initiated in the area should be taken up only after a detailed study of the region and slope protection should be carried out if necessary

3. In the construction of roads, irrigation canals etc. proper care is to be taken to avoid blockage of natural drainage.

4. Total avoidance of settlement in the risk zone should be made mandatory.

5. Relocate settlements and infrastructure that fall in the possible path of the landslide.

6. No construction of buildings in areas beyond a certain degree of slope.

7. Communities can play a vital role in identifying the areas where there is land instability.

8. Compacting ground locally, slope stabilization (procedures such as terracing and tree planting may reduce damages to some extent) and avoiding construction of houses in hazardous locations are something that the community has to agree and adhere to avoid damage from the possible landslides. This would also reduce the burden of shifting of settlements from hazardous slopes and rebuild in safe site as it is less practical to do on large scale.

2.3.2.5 Lessons Learnt

1. The whole region is composed of soft Phyllite, Schists and Archean gneiss and has deep between 20 to 60 degrees. The soft sedimentary rocks are more vulnerable to erosion.

2. Due to the presence of the Mirik lake, there is continuous percolation of water through the soil pore space and the joints and cracks of the parent rocks and this percolation rate is enhanced with the onset of the Monsoon.

3. In Mirik, the cutting of the vegetation is significant for tea cultivation. The removal of vegetation reduces the cohesiveness of the soils and the parent body. Thus, it has enhanced the vulnerability of landslides with the addition of heavy rainfall in the surroundings of Mirik.

4. The continuous construction of the buildings and roads has accelerated the vulnerability of the landslide at Mirik, Kalimpong, Kurseong and Darjeeling.

5. With the increase of the urbanization and tourism industry in Darjeeling Himalayas, the use of non-biodegradable matter is increased that further prevents the movement of the natural percolation of water through the soil pore space and parent body. Thereby, the cohesiveness of the parent materials is disrupted that results the occurrence of a landslide during June-July.

2.3.2.6 References

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2. https://www.thehindu.com/news/national/other-states/28-killed-in-darjeeling-landslide/article7374505.ece
3. https://tribune.com.pk/story/912843/landslides-kill-at-least-11-in-indias-darjeeling
4. Biswas, S.S., & Pal, R. (2016). Causes of Landslides in Darjeeling Himalayas during June-July, 2015. Journal of Geography & Natural Disasters, 6.
5. https://economictimes.indiatimes.com/nation-world/heavy-rains-trigger-landslides-in-west-bengal/ndrf-jawans-search-for-dead-bodies/slideshow/47935633.cms67

2.4 SIKKIM

The state of Sikkim is susceptible to landslides owing to the slope instability, weak composition of the soil or rock structures. Some of the factors causing slope instability are rain, flooding, seismic events, removal of vegetation, construction activities etc. The Multi Hazard Risk and Vulnerability Assessment prepared by SSDMA shows the Susceptibility/Vulnerability to Landslide Hazard in the four districts of Sikkim.

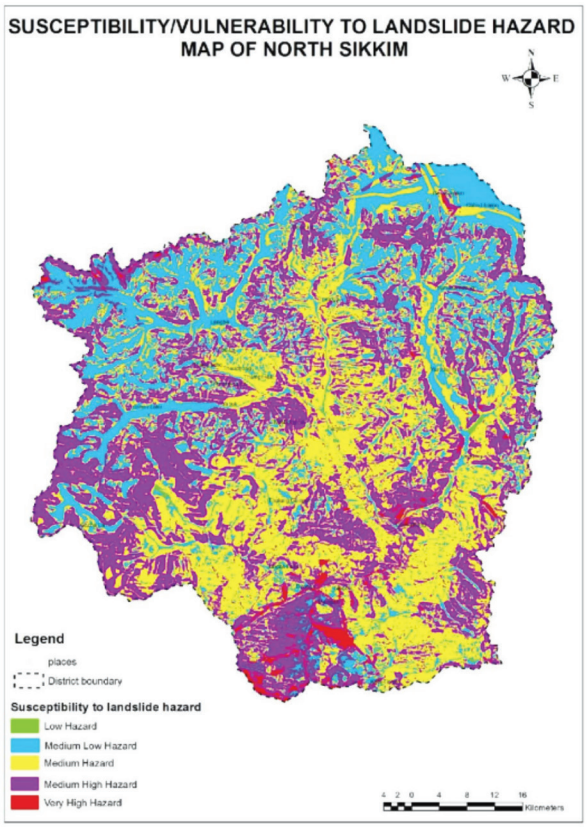


Figure-83: Landslide Susceptibility/Vulnerability Zones In Sikkim (Source: http://www.ssdma.nic.in/Uploads/PdfFiles/multi_hazard_risk_and_vulnerability_assessment_of_sikkim.pdf)

Connectivity in the National Highway 31A, the only life line of Sikkim, is frequently disrupted for long spells during the monsoons, causing shortages in supply of essential commodities and inconvenience to travellers.

Table 10 Record of past landslides (Source SDMP 2015)

LANDSLIDE NAME	TYPE OF SLIDE AND MATERIAL	MAGNITUDE AND INTENSITY	AREA IN DANGER	TRIGGERS	WARNING	STRIKE TIME	DAMAGE DONE
9th mile NH 31 A, Namli	Rotational (deep) sheared phyllite and quartzite debris	30ha. Slow slump, creep subsidence	NH 31A, Namli Village.	Weak geo, sleep slope, high water regime vibration	Subsidence bent trees seepage	1957	NH 31A, houses land forest
Manul	Debris toppie Gneisses, Schists	Debris avalanche	North Sikkim Highway	Steep Slope, Weak Geology, Heavy rain	Sudden	11/9/1983	65 dead GREF camp wiped out
Burdang, Singtam, Rangpo	Translational (shallow) faulted and joint Phyllite & Quatzite rock debris	10ha fast, rock/soil/ topple avaianche	NH 31 A State road Slilinge RF	Weak geo, steep slope, high rainfall, vibration	Fault and cracks in rocks, rock/ soil topple	October 1997	NH31A, Sillinge RF
Tsochen, Pheri	Complex roci and over burden debris	Huge fast avaianche	Rongli Bazar	Heavy rain thick debris on steep slope	No waming	21/5/1997 12:30pm	7 persons dead, 1 injured
Gangtok and vicinity	All type rock/soil materials	Wide spread fast mud and debris flow	Development Rongnek Syari, Mintokgang. Sichey	Heavy rain overflow of drain water etc	2-3 days before strike, cracks in roads and subsidence	8-9-30pm 8/6/97	43 persons dead, 300 house completely 1000 partially
Deoali, Gangtok	Mudslide (shallow) Rock/soil/ Construction materials	Localised Fast flow and avaianche	Kopibari school area,deorali	Water supply pipe burst and rain	No wamng	9.30pm 5/9/95	32 people dead, 08 houses completely

Gyakshing bazaar	Translational (shallow) Rocks and soil debris	Localised Fast Avainche	Road to Kyongsa nad Legship and Houses	Wayward rain water	No warming	Morning 26/0/2000	05 persons dead, 28 families evacualed
Racdong	Rotational Boulders, Debris, Soil	Large	3rd Mile Rakdong	Steep siope Weak geology rain	Presistent rainfall subsidence bent trees	12:30AM 26/9/2005	03 person dead
Chawang	Complex gneisses, schist debris & boulders	25ha. Fast Rock/Soil falls	North Sikkim Highway	Steep slope Loose Overburben Vibration rain	Subsidence Persistent rain	19/7/2005	41 families
Sardong	Rotational, Complex Debris	Widespread avalanche s	Dentam PElling road	Steep slope Weak rock Subsidence heavy rain	-	30/9/2005	15 houses
Manzing	Complex	Massive fast avalanche	22Kms from Ravangla to Lingmoo	Very high rainfall steep slope weak geology	Persistent rain, Subsidence	5pm 24/9/2005	07 families dead 28 families evacuated

Some brief case studies are discussed in the next section:

2.4.1 THE 9th MILE LANDSLIDE ON GANGTOK-SILIGURI ROAD

2.4.1.1 Introduction

The landslide is located at the ninth milestone on the Gangtok - Siliguri Road in the; State of Sikkim, on the National Highway 31-A. The road was built in 1957. Since 1957 several times landslide happened in the area. However, a major landslide occurred in July 1966 and 1972.

2.4.1.2 Impact

1. The National Highway was built in 1957 and a contour drain and a masonry toe protection wall were provided. During the floods of 1959, the protective work proved to be futile. Some parts of the downhill slope faded, along with the entire vegetative cover.
2. In the following years, tension cracks were observed uphill, fissures and cracks widened and the accumulated disintegrated rock mass gradually descended along with the surface run-off.
3. The surface movement of the loose debris gradually made the slopes uphill and downhill devoid of vegetation.

4. Further, this particular road spot developed into a major traffic hazard paralyzing movement, especially during the monsoon season.
5. In 1963, the road at the slide spot sank by 3 m vertically and also shifted laterally on the downhill slope by about 15 m. By December 1964, the crown of the slide reached about 60 m above the road enveloping a length of about 100 m.
6. A major landslide occurred in July 1966 when the total sinking of the road was reported to be about 20 m resulting in the total closure of the road.
7. The damaged road length extended to about 200 m with the crown of the slide moving to about 70 m.
8. Sausage spurs, which were constructed to protect the toe of the slope from river erosion, were washed away. The road alignment was back-cut into the hill by 50 m in order to keep the communications through.

2.4.1.3 Actions Taken

1. There was no systematic management of the landslide until 1967 except for the periodical maintenance of the road.
2. The maintenance was also restricted to the times when either the debris got piled-up or unacceptable subsidence occurred at this location.
3. An investigation was taken up in 1967 by the Central Road Research Institute (CRRI), at the request of the field authorities, to look into the cause of slope instability and recommend corrective measures.
4. The field authorities reported frequent lateral as well as vertical shifts of the road preceding every slide. Going up the hill, one could see a series of tension cracks of the retrogressive type. These tension cracks, left uncared for, served as water flowing traps fuelling instability.

2.4.1.4 Recommendations

The remedial measures were drainage centered. Three rows of interconnecting lined catch water drains built on the slope above the road helped in purveying water to the river through a system of culverts and chutes. Other protective measures included massive reinforced concrete toe wall and spurs to divert the river water away from the slide area. The existing spurs, gullies and streams were made use of while designing the drainage pattern. Terracing of the uneven downhill slope and vegetative turfing were the other measures applied.

Since the landslide first occurred in 1957, several protective measures such as catch-water drains, toe walls and breast walls were provided to meet the immediate needs. None of them survived for more than two seasons. Even after a detailed investigation in 1967, leading to the recommendation of the protection measures, the field authorities could not lake up most of the suggested works but implemented some drainage and restraining works. These provisions could not combat the fury of nature and collapsed without making their contribution. Financial constraints, short working season and oilier pressing obligations were some of the unavoidable situations forcing the field authorities to resort to part implementation of the remedial package.

There were unprecedented floods in the region in 1968 and 1972 and the landslide extended both side and upwards affecting a road length of about 300 m. Several landslides occurred during these floods all along NH 31 A and in neighbouring highways. However, no concerted effort could be mobilized to take up all corrective measures at Mile 9. It was only in 1974 that a conscientious effort was made by the field authorities to implement all important measures as a special and emergent case in as short a period as possible. The need for each of the measures was reassessed in the background of the change in the configuration of the slide area. They included drainage measures, like lined catch-water drains above the crown and through the tongue of the slide, a vented causeway and side drains, formation cutting and filling, restraining structures like retaining walls and check-walls, buttressed toe wall with a stone-pitched apron as a measure against flood erosion, terracing of the downhill slope and turfing of the slopes

2.4.1.5 Lessons Learnt

1. It was heartening to note that there had been no distress of the road whatsoever either by way of sliding or subsidence until 1978 shows the stable slope uphill of the road as well as the riding quality of the pavement at Mile 9. The downhill slope was also stable with plenty of vegetation all over.

2. In view of the continued satisfactory performance for four consecutive seasons, there was some laxity in the maintenance operations. An inspection of the catch drains on the uphill slope showed that there were cracks in some places resulting in minor damages. The steep chute on the downhill slope cracked and as a result, it was detached undermining its base by causing the gushing of water through the cracks.

3. On account of this, proper drainage of surface run-off was affected to a minor degree. Minor subsidence of the order of 10 to 20 cm was reported along the road causing damage to the pavement crust. Prompt action was taken to fill up the deficiencies. The need to maintain the protective works in a state of good repair was thus felt and called for vigilance on the part of the supervising authorities as the stability of a potentially unstable hill slope or of a hill road demands excellent drainage conditions. Some of the structures which fall under this category are catch-water drains, breast walls, retaining walls, chutes, road side drains and toe walls.

2.4.1.6 References

1. http://sikenvis.nic.in/writereaddata/Vol-II_Land%20Environment.pdf

2. ICIMOD Report, 1996. Landslide Hazard Management and Control in India, prepared by V. C. Thakur. http://apps.icimod.org/elibrary/uploads/ftp/landslide%20hazard%20management%20and%20Control%20in%20India.pdf

2.4.2 LANDSLIDE ON SILLIGURI-GANGTOK ROAD

2.4.2.1 Introduction

Heavy rains on (July 11, 2021) triggered a major landslide on the National Highway-10 which connects Gangtok (Sikkim) with Siliguri (West Bengal).



Figure-84: Accumulated Debris on Siliguri Gangtok Road (Source: ZEE news, July 11, 2021)



Figure-85:Debris flow on siliguri Gangtok road (Source: ZEE news, July 11, 2021)

2.4.2.2 Impact

Heavy rain triggered a series of small landslides and a major one on the 29 Mile area between Teesta and Rambi in West Bengal, completely blocking the highway and traffic movement was affected. Serpentine queues of vehicles were witnessed for more than 1 km on both sides of the landslide spot. The NH10 road link between Sikkim and West Bengal keeps getting affected due to landslide damage triggered by heavy rainfall during the monsoon season.

2.4.2.3 Actions Taken

1. Border Roads Organisation (BRO) workers and officials engaged in clearing the highway.
2. Many light vehicles were detoured via Darjeeling in West Bengal to reach their destinations.

2.4.2.4 Recommendations

1. The concerned department to evolve a mechanism for clearing access routes in order to facilitate search and rescue operations.
2. Arrangement for food, clothing, blanket/bedding, drinking water, sanitation and hygiene, lighting arrangements and essential medicines.
3. Deployment of mobile hospitals in affected areas for the treatment of victims.

2.4.2.5 Lessons learnt

1. The stability of a natural slope in unsaturated ground conditions needs to be evaluated, using a combination of the progress of moisture infiltration into unsaturated slope and the conventional slope stability analysis.
2. Always look out for features indicating deterioration or movements on slopes like tension cracks, erosion gullies on slopes or toe cutting at the slopes; Study the drainage pattern particularly blockings and changes in drainage channels.

2.4.2.6 References

1. https://zeenews.india.com/india/heavy-rains-trigger-major-landslide-on-nh-10-connecting-gangtok-with-siliguri-traffic-diverted-2375548.html
2. https://news.knowledia.com/IN/en/articles/heavy-rains-trigger-major-landslide-on-nh-10-connecting-gangtok-with-c5cb215e3ace73afd68d5fc3bb4bfb8658f47db9

2.5 KERALA

Kerala is geographically boarded on the west by the Arabian Sea and the east by the Western Ghats. In its north is Karnataka State and to the east is Tamil Nadu State. Kerala is multi-hazard prone. Kerala has a Human Development Index (HDI) of 0.79 which is the highest in the country (Government of India, 2016). HDI is a composite index of consumption rate (proxy to purchasing power), education and health, which is an indicator of socio-economic vulnerability. of the population. The higher the

HDI, the higher is the coping capacity, but greater is the cumulative loss potential and thus a higher degree of risk. Thus Kerala has a higher degree of disaster risks as compared to the rest of the country.

The highlands of Kerala experience several types of landslides, of which debris flows are the most common. They are called 'Urul Pottal' in the local vernacular. The characteristic pattern of this phenomenon is the swift and sudden downslope movement of high water-saturated overburden containing a varied assemblage of debris material ranging in size from soil particles to boulders, destroying and carrying with it everything that is lying in its path. The west-facing Western Ghats scarps that run the entire extent of the mountain system are the most prone physiographic unit for landslides (Thampi et al., 1995). Studies conducted in the state indicate that prolonged and intense rainfall or more particularly a combination of the two and the resultant persistence and variations of pore pressure is the most important trigger of landslides.

Between 1961 and 2016 a total of 295 valuable lives were lost in 85 major landslide events. The most severe, in terms of fatalities, was the Amboori landslide (Thiruvananthapuram) of 9th November 2001 that resulted in 39 casualties. Population of 10 taluks of Kerala is highly vulnerable to landslides in terms of population density; 25 taluks come under moderately vulnerable category and 14 come under least vulnerable category. Kuriakose et al. 2009 on the basis of the investigation reports from various research institutions and news paper reports prepared a district-wise inventory of landslides and identify the most prone regions (Table-11).

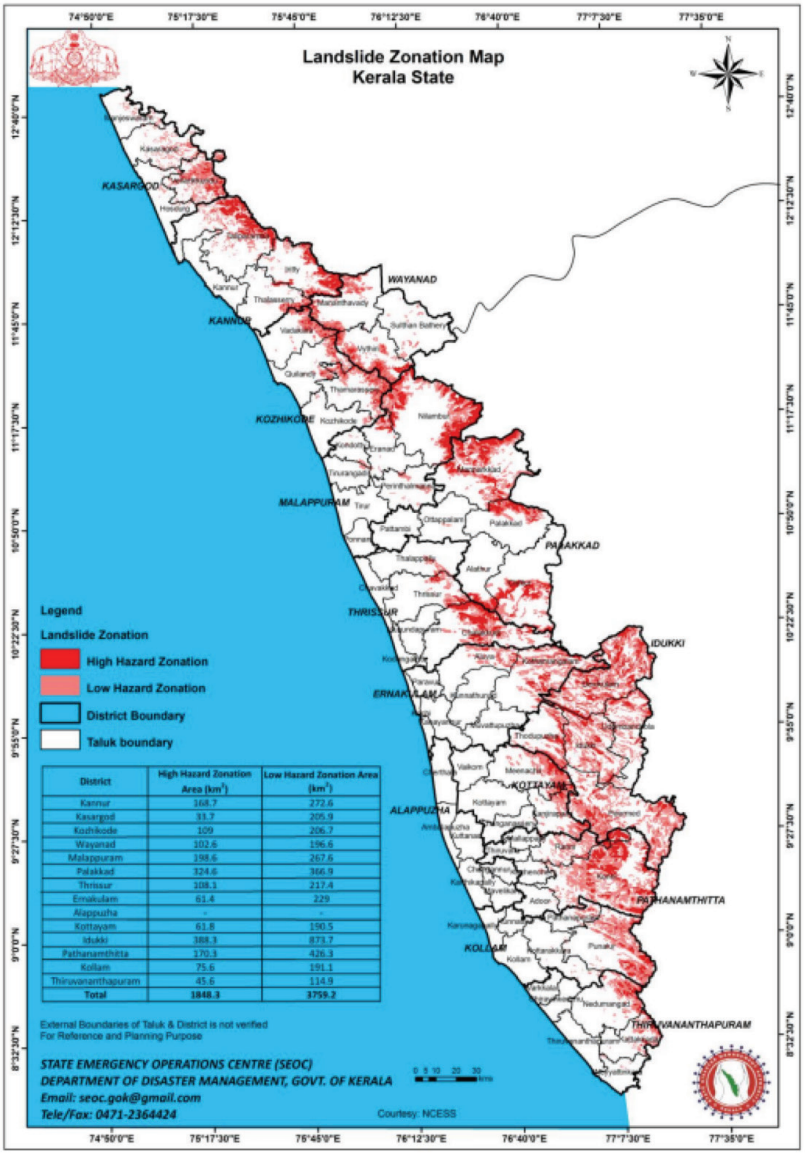
Table 11 Major landslides in Kerala (Kuriakose et al. 2009)

S. no.	Location	Type	Taluk	District	DD/MM/YY	Deaths
1	Mundakay	C	Vythiri	Wayanad	01-7-84	14
2	Kumpanpara (Moolamattom)	DF	Thodupuzha	Idukki	26-6-85	9
3	Koodaranji	DF	Koyilandi	Kozhikode	01-7-91	4
4	Kappikalam (Padinjarethara)	DF	Vythiri	Wayanad	19-6-92	11
5	Adivaram (~100 slides)	DF	Meenachil	Kottayam	06-10-93	1
6	Bison valley	DF	Udumbanchola	Idukki	14-7-94	7
7	Pazhampallichal	DF	Devikolam	Idukki	21-7-97	9
8	Ozhuvathadam	DF	Devikolam	Idukki	21-7-97	2
9	Valara	RS	Devikolam	Idukki	21-7-97	1
10	Cheeyappara	DF	Devikolam	Idukki	21-7-97	1
11	Idichakkaplamoodu (Trivandrum–Nagercoil railway line)	RS	Neyyattinkara	Trivandrum	15-11-98	3
12	Pamba	RS	Adoor	Pathanamthitta	15-1-99	25
13	Periyanmala	DF	Meenachil	Kottayam	99	
14	Chundakkadu (Nelliyampathi)	DF	Chittur	Palakkad	25-8-00	1
15	Cheenikuzhi	DF	Thodupuzha	Idukki	09-7-01	3
16	Amboori	DF	Neyyattinkara	Trivandrum	09-11-01	39
17	Venniyani mala	DF	Thodukuzha	Idukki	09-7-02	1
18	Kaithapadam Thooveri Parambil (Pottammel–Palazhi road)	DF	Kozhikode	Kozhikode	06-6-04	2
19	Nittukottamala	DF	Vadakara	Kozhikode	10-8-04	10
20	Vellikulangara	DF	Mukundapuram	Thrissur	14-7-05	2
21	Anthoniar Colony (Munnar)	C	Devikolam	Idukki	25-7-05	4
22	Vallamthodu	DF	Manathavady	Wayanad	23-6-07	4
23	Kairadi	DF	Chittur	Palakkad	17-7-07	1
24	Mysoorpetta–Thottamukam	Sl	Kozhikode	Kozhikode	17-7-07	1

25	Panakkachal	DF	Kozhikode	Kozhikode	17-7-07	1
26	Anayode	DF	Kozhikode	Kozhikode	17-7-07	1
27	Alappara	DF	Eranadu	Malappuram	17-7-07	1
28	Edavanna	RS	Eranadu	Malappuram	17-7-07	2
29	Kavalupara	RS	Alathur	Palakkad	17-7-07	1

Trivandrum is Thiruvananthapuram; DD/MM/YY is the date

DF debris flow, *Sl* slump, *C* complex slide, *RS* rotational slide, Trivandrum is Thiruvananthapuram Date: dd/mm/yy



District	High Hazard Zonation Area (km²)	Low Hazard Zonation Area (km²)
Kannur	168.7	272.6
Kasargod	33.7	205.9
Kozhikode	109	206.7
Wayanad	102.6	196.6
Malappuram	198.6	267.6
Palakkad	324.6	366.9
Thrissur	108.1	217.4
Ernakulam	61.4	229
Alappuzha	-	-
Kottayam	61.8	190.5
Idukki	388.3	873.7
Pathanamthitta	170.3	426.3
Kollam	75.6	191.1
Thiruvananthapuram	45.6	114.9
Total	1848.3	3759.2

Figure-86: Landslide susceptibility map of Kerala
(Source: Kerala State Disaster Management Plan, 2016)

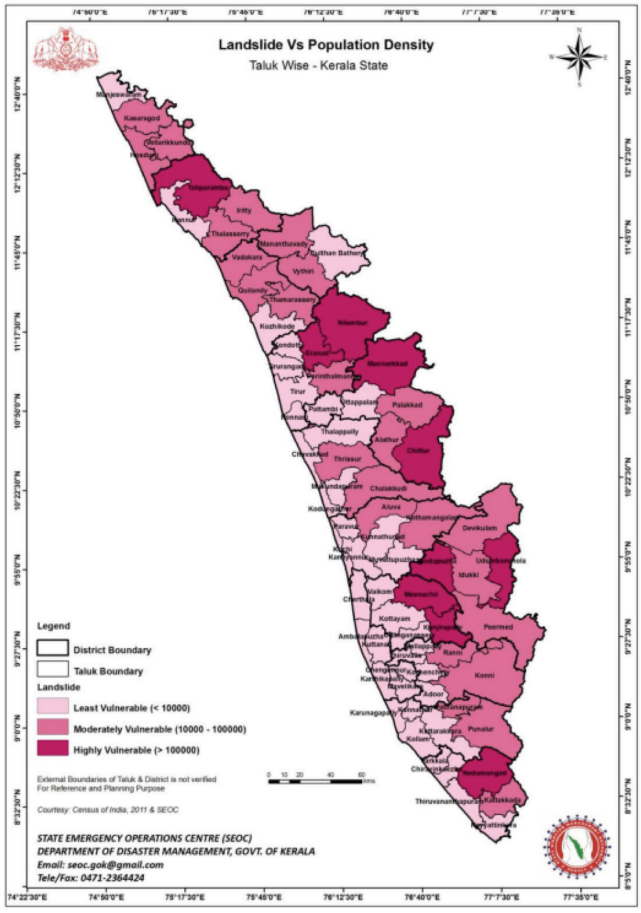


Figure-87: Taluks of Kerala ranked with population vulnerability to landslides (Source: Kerala State Disaster Management Plan, 2016)

2.5.1 AMBOORI LANDSLIDE

2.5.1.1 Introduction

The incident of landslide took place on 9 November 2001. There was a very heavy downpour accompanied by lightning and thunder from 6.40 p.m. to 8.15 p.m. on 9.11.2001 at Kurisu malai and the slide occurred between 8.30 p.m. and 8.45 p.m. The failed slope is located in the Kurishumala hills and has a gradient of 36°. The maximum elevation is 355m from MSL. The head of the scar of the debris flow starts from a height of 244m and extends down to Amboori-Kumbichal road, which is located at a height of 160.

A pall of gloom descended on the hilly Amboori and Neyyattinkara areas, which were never identified as landslide-prone despite the presence of the Neyyar dam nearby. The rubbles of the devastating

landslip occurred at Poochamukku in neyyar dam on the slopes of the western ghats, Near Thiruvananthapuram the house where a large number of people had gathered for an engagement ceremony, was completely razed trapping relatives and friends of the family. According to eyewitnesses, in the stunning impact of the landslip, four houses on the upper part of the rocky 'kurisumala' came down collapsing on the concrete house on the slope of the hill. Eyewitnesses said groaning and cries for help could be heard from the rubbles. Most of the bodies extricated were crushed and mutilated.

2.5.1.2 Impact

Everything happened in a fraction of a second. The Amboori landslide claimed 39 lives in 2001. The approximate volume of material involved in the slide was 5,000 m3. The slope was terraced for rubber plantation and an ephemeral stream was obstructed near the initiation zone. The runout reached 155 m downhill tracing the ephemeral stream, travelling a distance of ~1 km. The exposed bedrock at the hill summit routed significant amounts of water to the failure location. The L shaped slope cut for the road created an overhanging overburden through which the storm water was being discharged. This resulted in toe erosion of the already precarious slope. High intensity rainfall of 82.4 mm from 08.30 hrs to 20.30 hrs (~time of the event), preceded by an above average seasonal rainfall was identified as the trigger of the event.



Figure-88: Amboori landslide event on 9 Nov 2001 (Source: Kuriakose et al. 2009)

2.5.1.3 Actions Taken

1. The rescue operations, were carried out jointly by the military, para-military, Fire Department and police forces.

2. Only two survivors of the mishap survived and they were treated at Medical College Hospital, Thiruvananthapuram.
3. The Kerala Electricity Board restored power supply to Amboori area, the scene of the devastating landslide. Power supply to the Amboori area was totally disrupted following continuous torrential rains, accompanied by thunder and lightning, hampering rescue operations.



Figure-89: The police and rescue workers help clear the debris and find victims of a landslide at Amboori, near Thiruvananthapuram. (Source: The Tribune, 10th November 2001)

2.5.1.4 Recommendations

Some recommendations are drawn for land use and hydrological management and maintenance to reduce the probability of landslide initiation:

1. Ephemeral streams in the Western Ghats scarp faces shall be kept devoid of obstructions as they act as storm water drainage conduits during the monsoon season.
2. Buffer zones have to be created around all ephemeral streams where shrub and tree crops, preferably native species that offer significant root reinforcement should be planted.
3. Native grass species should be planted that are known to offer significant root reinforcement such as Vetiver (Chrysopogon zizanioides) (The Vetiver Network, 2005) and lemon grass (Cymbopogon citrates) along the walls of the sloping terraces and the banks of ephemeral streams to ensure stability.
4. All terraced slopes should have weeping holes along the terrace walls that would partly prevent the occurrence and persistence of high perched water levels.
5. Upslope side walls of roads that have overhanging regolith material should be terraced, covered with coir geotextites and planted with deep rooting grass and shrubs to ensure stability.
6. Measurements of rainfall, perched water level and discharge in the catchment should be continued for better calibrating and validating the models.

7. A more comprehensive state wide landslide inventory has to be prepared and a system for continuously updating this inventory should be made, making use of local knowledge.
8. Bio-engineering solutions such as planting crops that ensure root reinforcement and using geotextile produced from abundant locally available materials like coir fibres (Lekha; Vishnudas et al., 2006) not only are cost effective and affordable mitigation measures, but are also environment friendly.

2.5.1.5 Lessons Learnt

Year after year one or more, natural hazards, such as rains floods, and landslides occur in various parts of the state. The only option societies have is to understand them and plan their lives and investments around them. To do so, a thorough learning exercise is essential. In the following sections, a few lessons and suggestions are made:

1. Better weather forecasts are the need of the hour.
2. Prepare for a changing climate.
3. Land use planning is fundamental to risk reduction.
4. Risk-informed building codes are imperative: The use of timber for building roofs has almost disappeared and almost 100 per cent of new buildings in Kerala are built with reinforced cement concrete. Such buildings are not only damaged during natural disasters but also contribute to land settlement (in islands) and landslides (in the high ranges). It is high time that Kerala developed risk-informed building codes.
5. If water-linked hazards, such as landslides floods and droughts, in the state have to be controlled, water management efforts have to be unified, both administratively and substantively.
6. Information relating to natural hazards in the state should be granularized and percolated to every household and made available to the public in a form that is accessible to all. Any person who is planning to build a house, an investor planning a hotel, or a government agency planning a road, should have ready and easy access to the hazard maps.
7. We should aim to provide every stratum of the society with a basic understanding of disaster management by establishing a basic curriculum, which includes identifying hazards, setting up early warning measures, getting ready the required first aid, setting up relief camps and preparing for disasters.
8. We should plan to network and leverage the social systems. If people are trained in emergency response and the standard systems of the government, then one could have them interoperable so that the community initiates actions whenever and wherever a disaster happens and government reaches whenever they can and then supplement the efforts. That is the only way to achieve an effective DRR system in Kerala.

2.5.1.6 References

1. Kuriakose, S.L., Sankar, G. & Muraleedharan, C. History of landslide susceptibility and a chorology of landslide-prone areas in the Western Ghats of Kerala, India. Environ Geol 57, 1553–1568 (2009). https://doi.org/10.1007/s00254-008-1431-9.
2. Muthu RP, Muraleedharan C (2005) Causes and Mechanism ofAmboori Landslide of 9th November, 2001, Thiruvananthapuramdistrict, Kerala. J Geol Soc India 66(2):203–208.

3. Muralee Thummarukudy and Benoy Peter (2019); Leaving No One Behind: Lessons from the Kerala Disasters.

2.5.2 LANDSLIDE IN KERALA-2018

2.5.2.1 Introduction

Between June 1 and August 18, 2018, Kerala experienced the worst ever floods in its history since 1924. During this period, the state received cumulative rainfall that was 42% in excess of the normal average. The heaviest spell of rain was during 1-20 August, when the state received 771mm of rain. The torrential rains triggered several landslides and forced the release of excess water from 37 dams across the state, aggravating the flood impact. Nearly 341 landslides were reported from 10 districts. Idukki, the worst hit district, was ravaged by 143 landslides.

2.5.2.2 Impact

According to reports of the state government, 1,259 out of 1,664 villages spread across its 14 districts were affected. The seven worst hit districts were Alappuzha, Ernakulam, Idukki, Kottayam, Pathanamthitha, Thrissur and Wayanad, where the whole district was notified as flood affected. The devastating floods and landslides affected 5.4 million people, displaced 1.4 million people and took 433 lives (22 May–29 August 2018).The death toll due to landslides alone was 155. The total loss in various damages to infrastructure and other properties is estimated to be 40,000 Crores INR excluding the incredible topsoil loss in thousands of hectors of fertile land in the state especially in Wayanad and Idukki districts.



Figure-90: Rescue efforts at the Poovanchi area in Idukki's Kokkayar Panchayat where a landslide swept away several houses. (Source: https://www.onmanorama.com/news/kerala/2021/10/22/landslides-frequency-increase-kerala-climate-change-land-use-pattern.html)



Figure-91: View of Landslide in Kerala 2018 ; (Source: https://sdma.kerala.gov.in/wp-content/uploads/2020/08/NIDM-Study-on-Capacity-Needs.pdf)



Figure-92: Damaged Road due to Landslide in Kerala in 2018 (Source: https://sdma.kerala.gov.in/wp-content/uploads/2020/08/NIDM-Study-on-Capacity-Needs.pdf)

2.5.2.3 Actions Taken

The state government responded swiftly with rescue and relief operations and saved many lives by rapidly mobilising the following national forces:

- Kerala Fire and Rescue Services: 4,100 individuals and the entire rescue equipment deployed
- National Disaster Response Force (NDRF): 58 teams, 207 boats
- Army: 23 columns, 104 boats
- Navy: 94 rescue teams, one medical team, nine helicopters, two fixed wing aircrafts and 94 boats
- Coast Guard: 36 teams, 49 boats, two helicopters, two fixed wing and 27 hired boats
- Air Force: 22 helicopters from Air Force and 23 fixed wing aircrafts
- Central Reserve Police Force: 10 teams
- Border Security Force: Two companies and one water vehicle team.

In addition, the fishing community of the state rendered phenomenal voluntary assistance towards search and rescue in the flood affected areas. Nearly 669 boats that went out with 4,537 fishermen are estimated to have saved at least 65,000 lives. The Government of India announced an additional assistance of INR 600 crore (USD 85 million) which included ex gratia payment of INR 2 lakh (USD 2,800) per person to the next kin of the deceased and INR 50,000 (USD 700) per head to those seriously injured. The Ministry of Rural Development sanctioned an additional INR 1,800 crore (approximately USD 260 million) under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) for 2018–19 for 5.5 crore person days of work.

2.5.2.4 Recommendations

1. Opening of new monitoring stations downstream of reservoirs to monitor the outflows and use these stations for developing correlation curves instead of using reservoir releases.
2. Installation of more real-time reporting rainfall stations either by IMD or by CWC using Satellite based or GPRS based telemetry.
3. Relocation of vulnerable houses which are at risk.
4. Prepare & encourage community to build flood resilient houses with available local resources.
5. For families who have lost their homestead, identifying possibilities of rental support, & construction of transitional shelters.
6. All reconstruction should consider resilience and environmental impact/ carbon footprint. Local resources should be mobilised as much as possible.
7. In Landslide prone zone, reconstruction should be carried out post study of land based on the stability & identified safe zones.
8. Joint planning for shelter recovery should be done with the affected people who have lost their house,with contribution from the owners of the house.
9. School development plan for each school comprising of but not limited to School Safety plans, School Disaster Management Plans including WASH and Child Protection Programmes.

10. Strengthening of infrastructures, facilities and services for undertaking landslides studies, research and management.
11. Sensitization and awareness among public, particularly affected communities and responsible officials / organizations .
12. Establish Demonstrative Best Practices of Landslides Management.
13. Better regulations and enforcement for landuse, construction and development including policy, advocacy, implementation, monitoring and management.
14. Training and Capacity Enhancement in the field of Landslides Risk Reduction and Management at local levels in the State is very much required. NIDM may support KSDMA and GSI along with other stakeholders in development and enhancement of the local capacity for landslides risk reduction and resilience.
15. There is a dire need for coordination, networking and linkage among different organizations and experts working on landslides in the state including KSDMA, GSI, NCESS, PWD, Department of Geology, Civil Engineering, Irrigation and Flood Control, Forest, Agriculture and other relevant departments / organizations.

2.5.2.5 Lessons Learnt

1. Stringent laws must be enacted for the construction of infrastructure in the high lands.
2. Land use pattern in high lands must be closely monitored.
3. Efficient early warning systems need to be built to mitigate disastrous landslide events.
4. Best of all, environment-friendly human settlements with the least impact on pristine earth must be encouraged.
5. Some control on human habitation in areas prone to landslides needs to be evolved so that loss of human life can be avoided.
6. These call for a proper land use plan to be evolved and implemented with a fair degree of conviction.
7. The landslides and the flood of 2018 was an episode which urged the people and the Government of Kerala to rethink policies from an environmental perspective. It shows the need to preserve nature and protect the lives and livelihoods of the people of Kerala, in the lap of Western Ghats.

2.5.2.6 References

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2.5.3 LANDSLIDE IN KERALA-2019

2.5.3.1 Introduction

During monsoon season in the year 2019, the incessant rainfall across the state of Kerala region affected most of the districts of the state viz. Ernakulam, Idukki, Thrissur, Malappuram, Palakkad, Kozhikode, Wayanad and Kannur. With the ground and the soil having become saturated with water and rivers flowing at dangerous levels, the heavy downpour on 8 August 2019 triggered severe "floods in several parts of Kerala". The heavy and prolonged rains were caused by a depression in the Arabian sea nearby. On following day, that is on 9, incessant rainfalls induced/triggered major landslides at Ipadi, Puttupala, Wayanad and Bhudanam, Neelambur, Mallapuram trapping several people under debris.

2.5.3.2 Impact

121 people have been killed due to the floods across the state of Kerala. Over 2 lakh people have been directly affected by the flood and have been shifted to 1318 relief camps in different parts of Kerala. Airport authorities suspended operations of the flood affected Cochin International Airport. The data from the Kerala State Disaster Management \ Authority states that, as many as 1,789 houses had been damaged fully in between 8 and 19 August, while the number of partially damaged houses is 14,542.

Districts that have been severely affected include Wayanad, Malappuram, Kozhikode, Kannur, Palakkad, Thrissur and Ernakulam district. Nearly 22,165 people have been shifted to relief camps.



Figure-93: A house hit by landslides, at Pothukal, Malappuram, Kerala in 2019 (Source: https://thewire.in/environment/kerala-rains-landslides-flood)



Figure-94: A mosque destroyed after being hit by the landslides at Pothukal in Malappuram. (Source: https://thewire.in/environment/kerala-rains-landslides-flood)



Figure-95: A view of Kavalappara, in Pothukal panchayat. Here, more than 50 persons were buried alive following a hill collapse (Source: https://thewire.in/environment/kerala-rains-landslides-flood)



Figure-96: A house at Kavalappara in Pothukal. The landslide is seen in the background. (Source: https://thewire.in/environment/kerala-rains-landslides-flood)



Figure-97: Rescue operations in Kerala in 2021 (Source: http://ndrf.gov.in/operations/landslide-kerala-2019)

2.5.3.3 Actions Taken

1. Kerala's State Disaster Management Authority, Police, Fire & Rescue Services along with the Indian Air Force, Indian Navy, civilians, volunteers like Seva Bharati, White Guard Volunteers, fishermen from coastal Kerala actively took part in the rescue operations in flood-affected regions.
2. 83 National Disaster Response Force(NDRF) teams were deployed in addition to the 173 teams of Army, Navy, Air Force and Coast Guard to take part in the relief operations.

3. Animal rescue was carried out by local NGOs and activists on ground mainly in places like Wayanad and Nilambur. Notable work was done by Sally Varma of Humane Society International/India in Nilambur where around 500 kg of dog food and more than 5000 kg of cattle feed and 2500 kg of goat feed was distributed to the starving animals.
4. In August 2019, Public has been very generous contributing to Chief Minister's Distress Relief Fund. As on 15 Aug 2019 at 1940 hrs income was 4368.2 Cr. (INR).
5. Immediate financial aid of up to Rs 10,000 each for all calamity-hit families which had suffered losses in the torrential rains. A sum of Rs 4 lakh to those whose houses had been fully damaged or had become uninhabitable and Rs 10 lakh to those who had lost their houses as well as land in the rain fury and landslides.
6. Kerala Govt announced Flood relief Package; Rs 10,000 Immediate Aid to Calamity-hit Families.
7. A rapid assessment of the safety of areas affected by landslides/debris flows and the sites were radial cracks where formed in the sloped due to aborted landslides were deemed necessary.
8. Accordingly, officers of Mining and Geology, Ground Water and Soil Conservation Departments were paired into 49 teams and trained by KSDMA with the assistance of landslide experts and Geological Survey of India. Each team had one Geologist and a Soil Conservation Officer.
9. In total 719 sites were investigated. Based on the site-specific investigations, the teams recommended dwelling units at 411 sites to be relocated.

2.5.3.4 Recommendations

In Kerala, rainfall increases steeply with elevation i.e. High rainfall and steep slopes render localities susceptible to landslides.

1. Avoid the construction of buildings and roads, quarrying or mining, replacement of natural vegetation by plantations or levelling of the land using heavy machinery.
2. Mining should be conducted for construction activities, but the authorities should ensure that it does not affect the environment. A study should be conducted to assess the extent of mining that could be allowed in an area. Permit should only be given after the detailed study.
3. Remedial measures in human settlements and crucial installations susceptible to landslides include adoption of scientific land use practices and regular scrutiny of geoscientific and meteorological machine data essential for making informed decisions.
4. Natural drainage courses need to be kept clear of slope modifications, leveling, improper terracing and alternate land uses. All drainage channels need to be cleared of the runoff debris to enable smooth channelized flow of surface water.
5. Construction of houses along hazardous zones prone to flooding must be strictly avoided.
6. Natural afforestation should be taken up for stabilization of the slopes and restoration of ecological balance.
7. Monitoring of rivers for floods in the area should be considered for prediction of multiple hazards and disaster risk reduction.

2.5.3.5 Lessons Learnt

1. A collective and collaborative team effort is imperative to avert such disasters in the future.
2. Lack of awareness among the local people also played a role in the damages caused. All small-scale landslips are an indication of major ones to follow and ought to be taken as a warning of sorts, but it is often ignored.
3. Disaster risk awareness and preparedness by the people in the hazard prone and affected areas are important considerations for hazard management. A participatory approach and community resilience model for risk management need to be implemented in landslide hazard zones.
4. As part of better disaster governance, we need to identify the vulnerable locations, assess their vulnerabilities and prepare appropriate policies and plans.
5. All development projects and plans that are increasing the vulnerabilities by the destruction of ecology and land use change should be reviewed and reversed.
6. Deforestation and construction close to ephemeral channels and the subsequent blockage of natural drainage has been another key ingredient for disaster. Steep cutting particularly for road building, resulting in day lighting of rock/overburden interface is another important aspect which needs immediate attention pertaining to rock falls.
7. Need of micro level mapping of geotechnical parameters and an extensive land use planning at the Panchayat level if such disasters are to be averted in the future. Making use of the available technology is the need of the hour.

2.5.3.6 References

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2.5.4 PETTIMUDI LANDSLIDE, 2020

2.5.4.1 Introduction

The landslide happened at 10:45 pm on August 6, 2020 at Pettimudi, a hamlet in Rajamala ward under Munnar village panchayat in Kerala's Idukki district. Workers of Kanan Devan Hills Plantations Company (P) Ltd were living in Pettimudi. Rajamala includes Eravikulam National Park and the landslide was triggered from a shola forest region in the national park. As power connection and mobile signals were disrupted in the inclement weather, the outside world came to know of the tragedy only the next day.

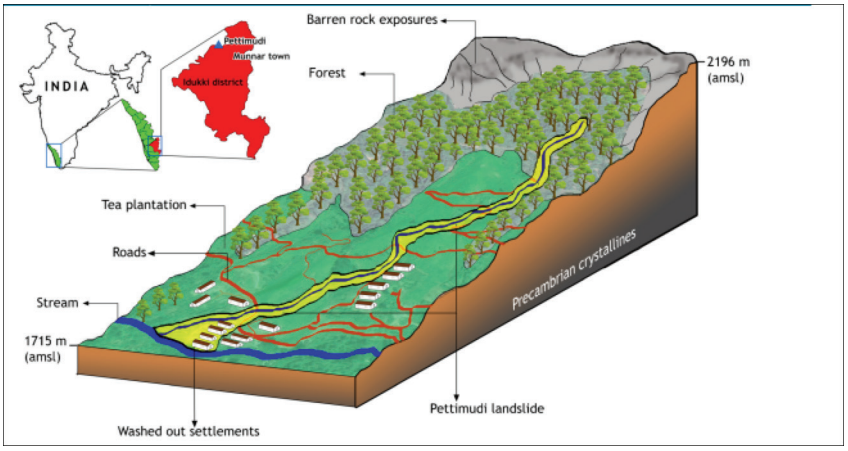


Figure-98: Location map and a schematic sketch of Pettimudi landslide, Kerala, 2020 (Source: Achu et al. 21)



Figure-99: An aerial view of the Pettimudi debris flow (Source: GSI report 2020)

2.5.4.2 Impact

The landslide struck the four labour quarters, locally known as 'layam', in the Nayamakkad Estate near to the Devikulam National Park. 83 people were living in 30 single-room, sheet-roofed quarters, provided by the estate. 12 of them were rescued by residents of another settlement. Only a handful of residents, who were away, have survived. 66 died and 4 went missing. The rescue operations went on for 19 days. A few bodies were found even 14km away from the accident site. Heavy rain, fog and the presence of wild animals posed a challenge to the rescue efforts. The automated weather station (AWS) of the forest department and the rain gauges installed by Kannan Devan Hills Plantations (KDHP) recorded an unusual amount of rainfall during those days.

The AWS of the forest department recorded 995 mm of rain in Rajamalai from August 1 to August 6.According to sources, the rains were so heavy that the AWS became dysfunctional. Meanwhile, the rain gauges of KDHP showed 61.64 cm of rainfall on August 6, the highest in a day in 40 years. The tea

plantations in Rajamalai began in 1910. Many of the line houses occupied by the plantation workers are about a century old.In fact, one of the rows of houses that were destroyed in the landslide was 100 years old and three other rows were rebuilt in 1981.



Figure-100: Officials said 83 people were living in 30 single-room, sheet-roofed quarters, provided by the estate (Source: https://indianexpress.com/article/explained/how-kerala-munnar-landslide-happened -6549373/)



Figure-101: The location where the landslide was triggered has a 40° slope and any slope above 20° is vulnerable to slipping during heavy rain. (Source: https://indianexpress.com/article/explained/how-kerala-munnar-landslide-happened-6549373/)



Figure-102: A look at the hamlet before and after the Idukki landslide
(Source: https://indianexpress.com/article/explained/how-kerala-munnar-landslide-happened-6549373/)

2.5.4.3 Actions Taken

1. The government of Kerala combined a group of local people and the National Disaster Response Force (NDRF) had started the rescue operations rapidly and effectively from the next day morning.
2. Many government agencies, including Kerala State Disaster Management Authority, district hazard analysts and other agencies were mobilized to the site to get involved in the necessary actions.
3. The National Disaster Response Force (NDRF), fire brigade and police personnel, along with local volunteers, carried the search operations for people missing after the landslide.
4. The health department made arrangements for DNA test to identify any recovered body.
5. The government had constituted a 12-member special committee headed by Munnar special Thahasildar.
6. Geological Survey of India being the nodal agency for landslide studies in the country, responded immediately and carried out post disaster landslide studies on 24 August 2018 to assess the slide, evaluate the causative factors and to suggest possible remedial measures.

2.5.4.4 Recommendations

Continuous rainfall with unique geomorphological and geological conditions leads to large-scale landslide hazards. It is necessary to investigate, monitor and identify potential future landslide areas in an effective manner by creating accurate landslide-susceptibility maps and by identifying the landslide-prone zones using artificial intelligence and geospatial techniques.

1. The implementation of a network of automated weather stations for early warning and evacuation.
2. The safety of buildings on the bank (within 30 m) of first and second order streams should be seriously looked into.
3. A new land use policy for the landslide-vulnerable zone should be implemented.
4. As a safety concern, it is recommended that the inhabitations in the hill slope area should be kept at a safer distance away from the tributary streamlets and also from the main river.
5. At the road bench level, it is suggested to provide a proper drainage arrangement with provision of a culvert of suitable dimension

2.5.4.5 Lessons Learnt

1. Many people could have been saved if there had been a timely intervention. In such cases, it's very important to have community based disaster management teaching.
2. If there was a forest or a lot more trees, the landslide wouldn't have extended three kilometers down from where it originated. From the government side, if it was demarcated as a dormant area, human settlement should have been discouraged, considering the geological peculiarities.
3. New construction shall be avoided in the stream flanks or at the mouth area of steeply sloping tributary streamlets.
4. Quarries and stone-crushing units continue to operate in ecologically sensitive areas. Highways are being unscientifically carved out of hills
5. Deforestation and encroachment of public land continues. And mega infrastructure projects are signed off in Thiruvananthapuram without a proper environment impact study.
6. Destabilisation of slopes due to cutting and creation of escarpments more than 3 m for construction purposes, construction of check dams on steep slopes, quarrying in vulnerable areas aggravated the vulnerability.
7. The critically-injured in the Pettimudi landslide had to be driven three-and-a-half hours down the twists and turns of Ghat roads to the Kolenchery Medical College Hospital.Need of super-speciality hospital in the high-ranges.



Figure-103: Pettimudi then and now (Source: https://english.mathrubhumi.com/news/kerala/one-year-of-pettimudi-landslide-a-scar-yet-to-be-healed-pettimudi-disaster-rajamala-hills-1.5888970)



Figure-104: Pettimudi then and now (Source: https://english.mathrubhumi.com/news/kerala/one-year-of-pettimudi-landslide-a-scar-yet-to-be-healed-pettimudi-disaster-rajamala-hills-1.5888970

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2.5.5 LANDSLIDE IN KERALA-2021

2.5.5.1 Introduction

As per Situation Report on Kerala Floods and Landslides (18-10-2021) Kerala witnessed high-intensity floods due to the incessant rains over the past few days. Residents got cut off in parts of the coastal state of Kerala as the rain started to intensify from late Friday, 15 October 2021. As per the authorities, the worst-affected areas were Kottayam and Idukki, which received 164.5 millimetres and 305.5 mm of rainfall, respectively. The heavy rains triggered landslides and swelled many rivers across the state.



Figure-105: Heavy rains and landslides in Kerala in 2021 (Source: https://economictimes.indiatimes.com/news/india/kerala-floods-photos-of-rain-fury-and-rescue-operations/rescue-operations/slideshow/87082122.cms)

2.5.5.2 Impact

Roads were swept away, houses got damaged and trees uprooted. Several villages in hilly areas were cut off. Around 50 individuals lost their lives and many of them were found missing. Many landslides occurred in Kottayam and Idukki districts, while 13 died in landslides at Koottickal, Kottayam. Several landslides were reported from various parts of the Kottayam district due to heavy rain. Koottickal village is located in the eastern part of Kottayam district of Kerala State, more than 10 thousand families are living in the village, most of them are dependent on agriculture-based livelihood activities, primary cultivation of these families are Rubber and other spices. Out of thousand families, 173 houses were washed away, hundreds of houses were damaged partially, many people lost their belongings and livelihood materials by the landslide during the month of October 2021.



Figure-106: A Kerala resident carries a dog amid the debris of his home after flash floods hit. Photograph: Appu S Narayanan/AFP/Getty Images (Source: https://www.theguardian.com/world/2021/oct/18/india-floods-deaths-heavy-rains-landslides-kerala)



Figure-107: Rescue workers push an overturned vehicle stuck in the mud and debris at a site of a landslide following heavy rains and floods in Kokkayar in India's Kerala state on Sunday. Photograph: AFP/Getty Images (Source: https://www.theguardian.com/world/2021/oct/18/india-floods-deaths-heavy-rains-landslides-kerala)



Figure-108: Landslide triggered by heavy rains in the western ghats mountains at Koottickal in Kottayam district, Kerala. (Source: https://economictimes.indiatimes.com/news/india/kerala-floods-photos-of-rain-fury-and-rescue-operations/landslide-triggered-by-heavy-rains/slideshow/87082224.cms)

2.5.5.3 Actions Taken

1. Authorities worked day and night on the ground to assist the injured and affected.
2. The Indian Air Force had inducted its medium-lift helicopters for flood relief efforts in the rain-hit districts of Kerala.
3. Fishing boats were being used to evacuate survivors trapped in Kollam and other coastal towns as sections of road have been swept away and trees uprooted.
4. National Disaster Relief Force and the armed forces are rehabilitating 2,000 people and shifting them to different relief camps, one dedicated to Covid-19 positive patient.
5. The India Meteorological Department (IMD) had predicted that the intense spell of rainfall activity over Kerala and Mahe, South Interior Karnataka and Tamil Nadu, Puducherry and Karaikal likely to reduce from today (18 October, 2021).
6. The Army, NDRF, police and the Fire Force along with the locals began rescue operations on Sunday morning at Koottickal in Kottayam district and Kokkayar in Idukki district, where over a dozen people were reported missing due to landslides accompanied by heavy downpour.
7. Distribution of dry ration kits to at least 5000 families targeting women headed households, marginal and landless farmers and families with disabled members in Kollam, Pathanamthitta, Alappuzha and Kottayam districts.

8. Distribution of hygiene kits along with Covid-19 safety kits including sanitary napkins for women and adolescent girls, sanitizers, masks, gloves, toothpastes, soaps etc.
9. Distribution of non-food items (NFIs) to 5,000 families including bed sheets, blankets, lunges for men etc.
10. Early recovery plan based on assessment.
11. The State Government has announced ex-gratia of Rs. 4 lakh to the families of people who were killed in rain-related tragedies. Minister for Revenue has made the announcement as a primary compensation to the kins of the victims.

2.5.5.4 Recommendations

1. Usually, soil study or soil piping phenomena are not done while constructing houses. Proper geological studies are needed, at least for new dwelling units.
2. We can reduce the intensity of disasters by listening to early warnings and disseminating them to targeted audiences. We need more studies in hazard-reduction areas.
3. There's also an urgent need for flood and landslide warning systems.
4. Given how the weather will become more erratic in the coming days, increasing both the probability and severity of rain disasters, the state must put in place a modern weather forecast system that can make predictions more accurate and useful.

2.5.5.5 Lessons Learnt

1. The rise in surface temperature in the Arabian Sea due to climate change has led to a 52% increase in the frequency of cyclonic storms—the reason for sudden spells of heavy rain.
2. The senseless destruction of nature—deforestation, quarrying, unregulated construction and encroachment of rivers, backwaters and wetlands—has rendered most areas prone to flooding and landslides.
3. Urgent support will help the people of the villages to mitigate the adverse health impacts related to the flooding and landslide and help them to cope with the ongoing COVID 19 pandemic.
4. Many people who have been displaced due to inundated homes and landslides do not have homes to go back to and the situation is expected to remain precarious for the next few months. Additionally, with damage to the houses and other sanitation facilities, urgent repair and rebuilding work initiative needs to be addressed.

2.5.5.6 References

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2.6 KARNATAKA

The state of Karnataka is one of the most disaster-prone state in southern India owing to its geo environmental diversity and vulnerability. The state is prone to different kinds of natural hazards (disasters) such as droughts, floods, cyclones, hailstorms, landslides and earthquakes. 80% of the state's geographical area is susceptible to drought, 22% of the state's geographical area is prone to a moderate earthquake, 24% of the state's geographical area is prone to cyclones and heavy winds and more than 30% of the state's slopes are prone to landslides. While many of these vulnerabilities are on account of natural causes many times human action often exacerbates is a contributing factor.

In the context of human knowledge vulnerability to disasters, the economically and socially weaker segments of the population are the ones that are most seriously affected. Within the vulnerable groups, elderly persons, women, children— especially women rendered destitute, children orphaned on account of disasters and differently abled persons are exposed to higher risks.

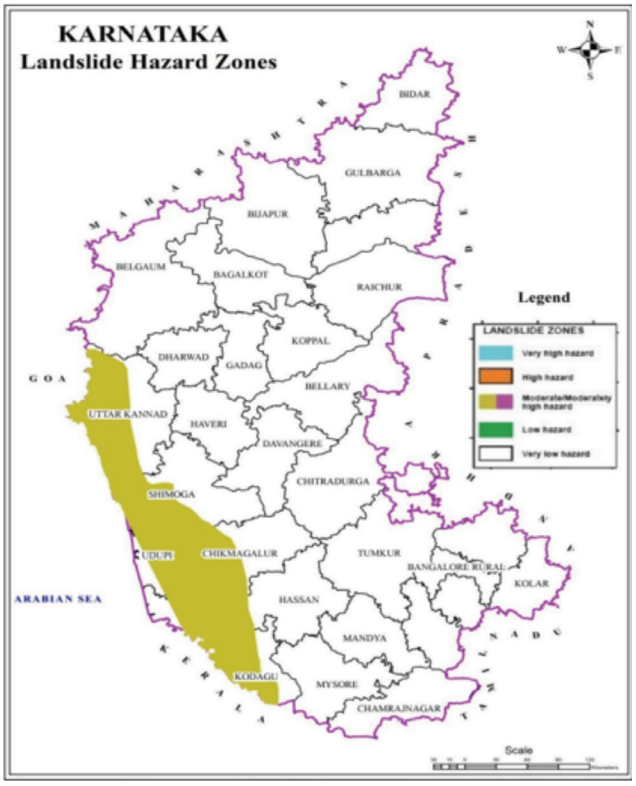


Figure-109: Landslide Hazard Zones in Karnataka (Source: Karnataka State Disaster Management Policy 2020)

2.6.1 KODAGU LANDSLIDE

2.6.1.1 Introduction

On 6 August 2020 at 02:30 am, on a day of heavy rain, near Talacauvery temple on Brahmagiri hills near Bhagamandala in Kodagu district, Karnataka witnessed a major catastrophic landslide. The Talacauvery slide that occurred in 2020 experienced multiple reactivations.

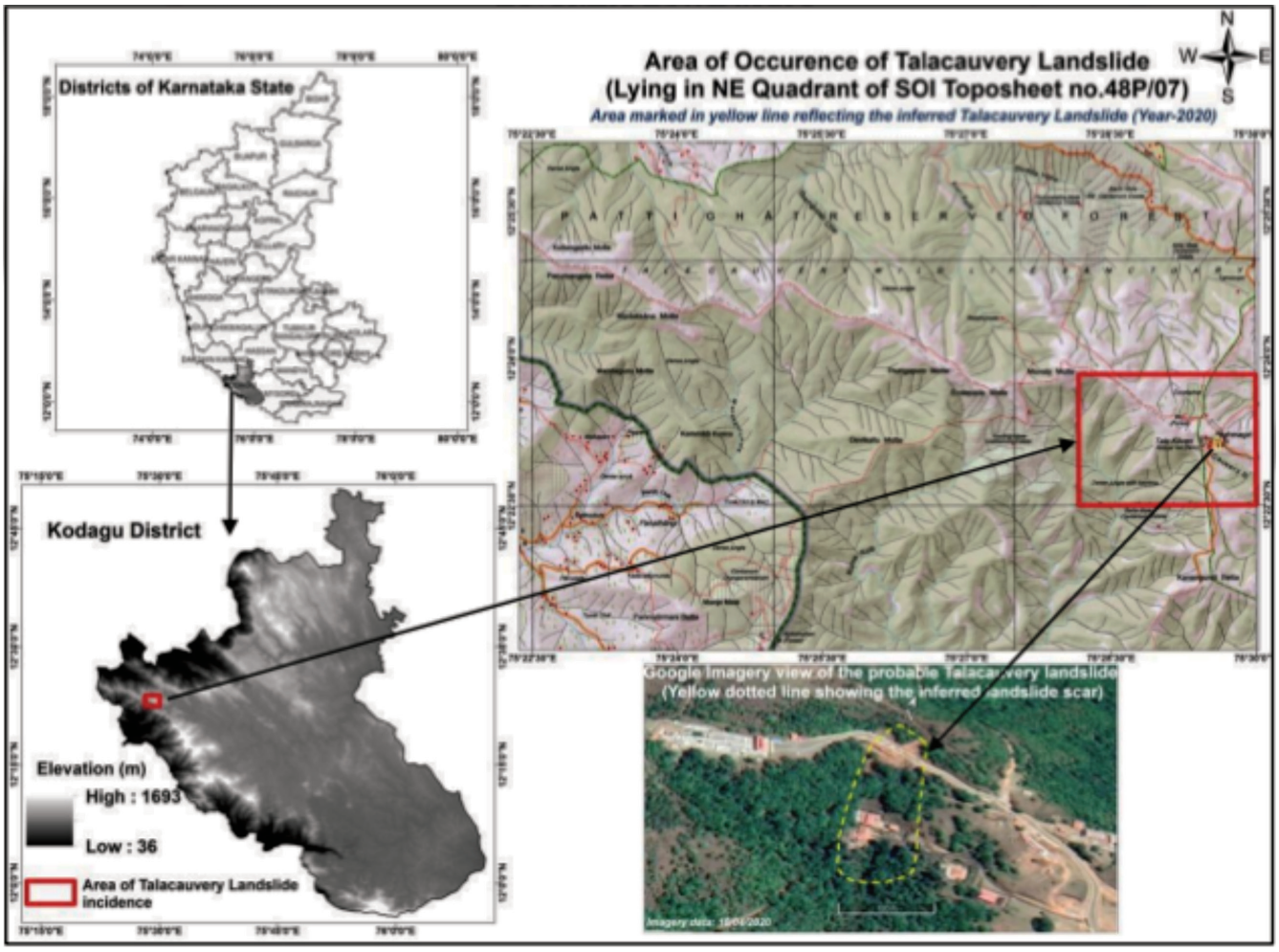


Figure-110: Location map of Talacauvery landslide investigated on Brahmagiri hills near Bhagamandala (Source: GSI report 2020)

2.6.1.2 Impact

The huge mass of saturated soil with overburden thickness of more than 10m rushed downslope, washed away settlements, vehicles and claimed 05 human lives. A considerable portion of landslide debris got deposited on the valley floor in smaller watershed, while the remaining portion entered in high-order channel due to overflown of Cauvery River. In this channel, where stream power was relatively large, the debris and soil carried by landslides were entrained by stream flow and debris flow was formed. Numerous streamlets were flowing over the debris accumulated on the landslide slip

plane. Approach road to Talacauvery Temple got blocked with saturated debris and rock boulders. The road got partly damaged and drainage along the slope was completely blocked with soil. The landslide in Talacauvery occurred along the approach road to Talacauvery temple. The temple is located on Brahmagiri hills near Bhagamandala in Kodagu District, Karnataka. Talacauvery, the place from where Cauvery River originates is an important pilgrim and tourist centre. The landslide was initiated in the year 2007 (Studied by AK Mishra, 2007; GSI), leaving a slip surface. Another slide in the year 2018 was occurred along this old slide scar (Ist Slip surface) developed second Slip surface. Heavy rainfall in the year 2019 caused ground water infiltration and transforming the older slip surfaces into new sliding surface 5 (the third slip surface). Consequently, the landslide was reactivated again (Year 2020) along the third sliding surface and thus exposing fourth slip surface. The old scars along with the active slide indicate that the slides are widening and the section is still unstable. Initially, south westerly concave slope has been cut for road construction making the slope unstable.

2.6.1.3 Actions Taken

1. National Disaster Response Force (NDRF) responded to calls made by residents near the affected area. It was near Talacauvery but the road had a lot of landslides and the NDRF team cleared the landslides on their way as they reached the spot.
2. All the rescued families being moved to relief centres were subjected to rapid antigen testing for COVID-19, before they were admitted to relief centres.
3. The administration had sent a recommendation to State Government to declare all missing persons as dead. Further to allocate compensation of Rs.5l/ person.

2.6.1.4 Recommendations

1. From lessons learnt during the 2018 experience, the District Administration's initiation for early evacuation helped in saving lives. Local people were the first ones to respond to these situations.
2. CCTV cameras to be installed in relief material godowns at Taluka level.
3. An eligible beneficiary list for new houses/ land to be given should be prepared in descending order of damage extent to their houses and be made public so that new land, houses can be allotted when available in a transparent manner.
4. During assessment of house and crop losses, the application-cum-inspection report shouldn't contain the compensation amount as it is dependent on the decision of the central, state govt and is subject to change. So only information like type of house, extent of damage in percent, type of crop, extent of damage should be filled.
5. Computer systems and power backup facility ought to be serviced well in time to ensure quick data entry

2.6.1.5 Lessons Learnt

Brahmagiri hills are in state of imbalance and it is advised to investigate the hill in terms of presence of any opening on upslope or mid-slope. Being a popular pilgrimage spot, the approach road to temple should be strengthed and supported by retaining structure on both side of road bench with proper lined drainage.

2.6.1.6 References

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2.7 TAMIL NADU

Tamil Nadu covers an area of 13 Million hectares and has a coastline of 1,076 kms which is about 15% of the coastline of India. The State is known for its multi-hazard vulnerability, the major natural hazards being Cyclonic storms, Urban and Rural floods and periodic Droughts. The State is also prone to Landslides, Sea Erosion and Sea Water Incursion in specific pockets. The State is also exposed to the risk of Tsunami.

Landslide is one of the major natural hazards that is commonly experienced in hilly terrains. The landslide hazard zonation atlas of India published by Building Materials and Technology Promotion Council (BMTPC), Government of India, categorized the Nilgiris district (Figure. 111) of Tamil Nadu State as one of the severe to very high landslide hazard prone areas of India. Landslides occur during the seasonal rains in the Nilgiris Hill Range and some of the major ones that have occurred are the Runnymede landslide, the Glenmore landslide, the Coonoor landslide, the Karadipallam landslide, Megamalai landslide and the Marapalam landslide. Besides Nilgiris, other districts in the State that have had the problem of the landslide are Salem, Erode, Coimbatore, Vellore, Dindigul (Kodaikanal hills) and Theni.

The Geo Technical Cell established by Government in The Nilgris District has studied the Landslide aspects exhaustively through Institute of Remote Sensing Anna University and potentially vulnerable Watersheds have been identified for treatment. Geological Survey of India issues alerts and warnings about landslides.

Category I: Landslides that may occur over or in close vicinity of inhabited areas such as urban settlements or fairly large rural settlements wherein a landslide can result in loss of human lives and dwellings on a large scale.

Category II: The landslides that may occur on the fringes of inhabited areas and result in limited loss of life and property.

Category III: Landslides which are fairly large and affect infrastructural installations such as strategic and important highways and roads, rail routes, hydroelectric and irrigation projects.

Category IV: Landslides of small dimensions that occur away from habitations and do not affect either humans or their possessions.

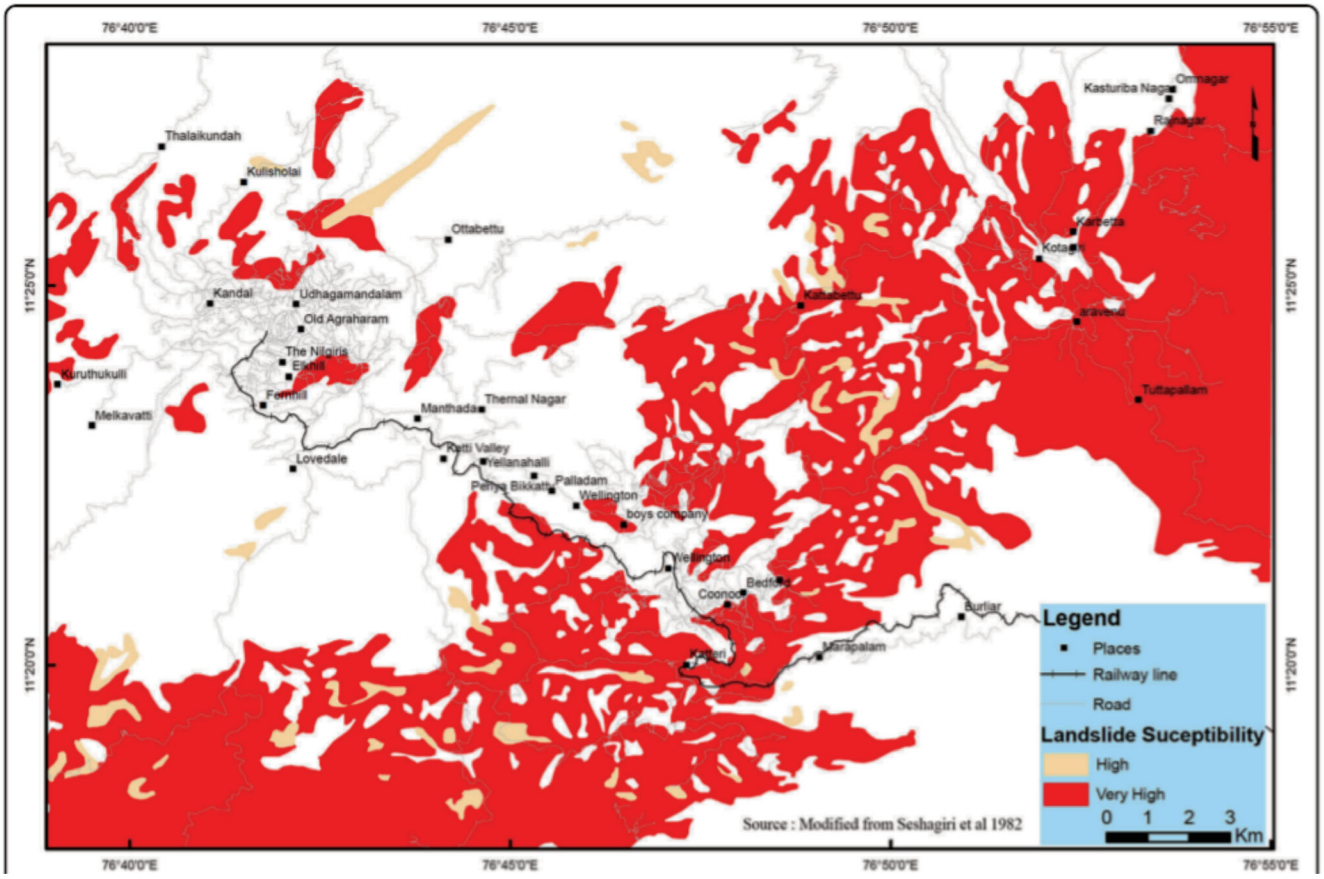


Figure-111: Detailed landslide hazard zonation map of Nilgiris carried out in 1980''s (Source: Thennavan 2020)

2.7.1 MARAPPALAM LANDSLIDE

2.7.1.1 Introduction

On 11 November 1993, a huge landslide was triggered by cloudburst at Marappalam.

2.7.1.2 Impact

12 persons lost their lives and 15 persons were missing. It is laid that 21 passengers were washed away with two buses. The debris was covered for almost several kilometres. Both road and rail connectivity was affected and the hill district was cut-off from the rest of the country. Mettupalayam Highway was washed away. The hill district was cut-off for almost 15 days. About 300 metres of the mountain rail tracks got covered in the debris and a long stretch of Coonoor-Mettupalayam Highway was washed away. Armed Forces laid temporary roads to transport food and other supplies.



Figure-112: Landslide near railway line (Source: https://simplicity.in/coimbatore/english/news/36877/Commemorating-the-worst-landslides-in-Nilgiris)

2.7.1.3 Actions taken

Considering the intensity of the slides, a study was ordered by then State government. Dr. V.K.S Varaadhan from National Geological Department, S.S Giri, Director of Chennai Geological Department and Researcher P.S Samraj studied the conditions at a village in Nilgiris. The researchers concluded that construction of buildings and teacultivation without proper drainage facilities led to the landslides. As the main communication corridor between Ooty and Mettupalayam was disrupted, the existing alignment of road was retained and three bridges were constructed on bedrock for proper rainwater drainage.

Gabions and retaining walls were constructed to arrest the movement of slide debris

2.7.1.4 Recommendations

1. The district administration and State government developed a master plan and several regulations were brought regarding building construction in Niligiri Hills.

2. Ganapathy and Hada, 2012 advised to use soil bio engineering technique of slope stabilization where ever is possible. It offers engineers a set of tools to complement those already available in solving range of shallow slope problems. The functions of soil bio-engineering works also have similar role

as civil engineering structures. The cost of implementing this technique also is very much less than the civil engineering measures. Also the natural beauty of the hills would be retained in the hill slopes. The Soil bio engineering provides improved landscape and habitat values. However the soil bio engineering is not suitable for all sites and situations, it is advised a detailed site specific study should be carried out before implementing this technique.

3. Training programs need to be organised for professionals such as civil engineers and geologist for landslide mapping, investigation techniques, analysis and observational practices.

4. Revisiting land use management in Hill areas where landslides have occurred will be essential to reduce damage.

5. Creating awareness in the community regarding safety measures in areas that are prone to landslides are necessary.

2.7.1.5 Lessons Learnt

1. The district is categorized under Severe to Very High landslide hazard prone areas. This indicates the area is well known for the danger of landslides and for the perennial threat to life and property.

2. Incorporate lessons learnt from earlier disasters.

3. The rapid urbanization development and land utilization has resulted in the deprivation of the mountain ecosystem and one of the impact of these man made activities is enlarged the occurrence of landslides which affect the environment.

4. The best way to manage this hazard is to identify safe zones for human settlements.

5. The planning principles of a landslide risk studies are: 1) gather accurate hazard information; 2) plan to avoid hazards before development and subdivision occurs; 3) take a risk-based approach in areas likely to be developed or subdivided; and 4) communicate the risk of hazards.

6. Soil bio-engineering can provide an effective means of treating sites where steep slopes and soil instability are resulting in revegetation problem.

7. The lack of awareness is one of the main issues among the public as well as the planners.

8. The Department of Science and Technology, Government of India has suggested having raise awareness among policy makers & planners at state/district and user institution level through conducting training programmes/workshops. Also awareness should be created among community leaders and general public affected by landslide hazards about the cost-effectiveness and benefits of taking landslide hazard mitigation measures.

9. The first responder's (local people) can take initiation in this regard with the help of Government officials to create awareness among the vulnerable community.

10. The elements at risk should be identified and a risk quantification study can be implemented for these vulnerable sites, so that this information can become vital in case of emergency response.

11. As suggested by National Disaster Management Authority (NDMA), Government of India in the National Disaster Management Guidelines for landslides, from the funds available with the District Planning and Development Council in landslide prone areas, a part will be allocated for the implementation of landslide management schemes in the Nilgiri district.

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2.7.2 UDHAGAMANDALAM LANDSLIDES, OOTY

2.7.2.1 Introduction

The Nilgiris district received heavy rain during North East monsoon in November 2009. Intense rainfall triggered landslides at more than 300 locations.

2.7.2.2 Impact

Landslides affected road and rail traffic and destroyed number of buildings which left more than 43 people dead and hundreds homeless. Mettupalayam – Coonoor – Ooty national highway had landslides at many places. The road got completely washed away at few locations and remained cutoff for three months. Nilgiri Mountain Railway (NMR), declared as World Heritage Site by United Nations, suffered severe damages. The railway track was hanging at many places with the supporting subgrade washed away and few bridges completely destroyed. The direct and indirect losses incurred by the landslides estimated to be more than rupees 200 crores (Chandrasekaran, S.S 2010). Some of the causative factors are:

1. Figure below shows the excavation of slope at toe for widening of road along Mettupalayam – Coonoor highway. Excavation of slope at toe reduces the shear strength of the soil due to yielding of soil mass.



Figure-113: View of excavation of slope at toe; (a) & (b) along Mettupalayam - Coonoor road network (Source: Chandrasekaran et al. 2016)

2. Figure below shows the vertical cut made all around the building located near Kattabettu for about 15.00m height. The lateral resistance of the slope has been completely removed all around the building due to an unplanned vertical cut. Removal of lateral resistance will lead to reduction in shear resistance and increase in shear stress thus result in slope failure. A building located at the crest of a slope in Kodappamandu near Ooty has been collapsed due to vertical cut nearer to the foundation of the house.

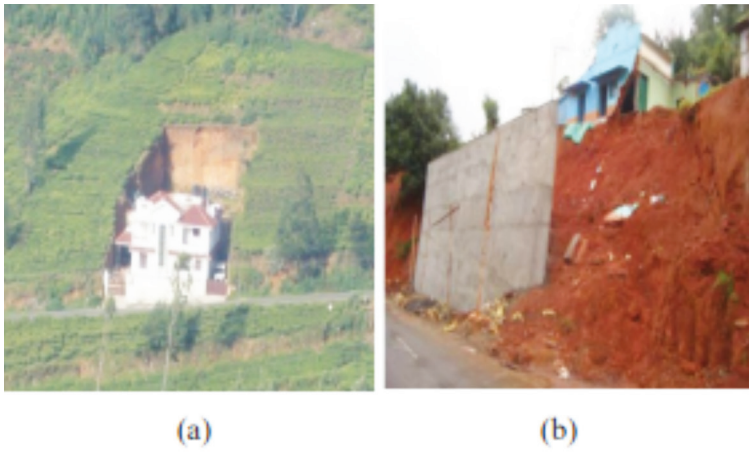


Figure-114: View of vertical cut; (a) all around the building (b) near to building foundation (Source: Chandrasekaran et al. 2016)

3. Drainage of water is one of the most effective techniques which increase stability of slopes. Figure below shows blocking of surface drainage systems (drainage pipes and drainage culverts)

along Metupalaym - Coonoor national highway and Aravankadu location. Blocking of drainage system allows the rain water to infiltrate into the slope, leads to build up of pore water pressure and thereby increases the driving force.



Figure-115: View of blocking of surface drainage pipe and drainage culvert; (a) & (b) along Mettupalayam-Coonoor road network (c) Aravankadu location (Chandrasekaran et al. 2016)

4. Figure 116 shows below removal of vegetation in a slope located at Chinnabikatty near Coonoor. Generaly plant roots provide a strong interlocking network to hold unconsolidated materials together and prevent flow. In addition to that, plants are useful in removing water from the soil which increases the shear strength. The removal of slope vegetation in Nilgiris may result in increasing either the rate of erosion or the frequency of slope failure. Figure below shows the dumping of loose soil on the slope surface near Coonoor. The additional weight due to dumping increases the shear stress. Whenever excavation of slope is made at the toe for widening of road, the unstable loose soil mass on the slope surface slide down and will disturb the road traffic.



Figure-116: View of Causal factors; removal of vegetation on slope surface; dumping of loose soil on the slope surface (Source: Chandrasekaran et al. 2016)

2.7.2.3 Actions Taken

1. Relief operations were undertaken.
2. The weather office warned of more rains and district officials have cautioned residents and tourists to keep off the winding roads in the picturesque hills famous for their tea.
3. People living on the slopes advised to move to upper reaches and administration issued a warning to tourists to stay away.
4. The district administration announced closure of educational institutions and a meeting convened to decide on declaring long holidays for schools, measures to be taken for repairing roads and relief work.

2.7.2.4 Recommendations

The remedial measures implemented so far in Nilgiris are construction of retaining walls and gabion walls.

1. (Chandrasekaran et al. 2016) observed that the weep holes provided in the retaining walls often got blocked with fine particles. This could be due to malfunctioning of the filtering arrangement provided in the weep hole during the time of construction of retaining walls. The similar problem has been observed in many locations throughout the district. Surface drainage systems provided throughout the district is also blocked due to lack of maintenance. rExcess pore pressure and seepage forces during the heavy rainfall decrease the effective stress of the soil and thus reduce the shear strength, consequently resulting in slope failure (Anderson and Sitar 1995, Cascini et al. 2010, Chandrasekaran et al. 2013a). Hence a proper subsurface drainage system and their periodic maintenance can be an effective solution in stabilization of slopes to avoid the slope failure under the influence of rainfall in Nigiris (Bhandari, 2006).
2. India's first subsurface drainage system by horizontal drains is implemented in Porthimund dam in Nilgiris district. The landslide occurred on the downstream side of dam in 1979 due to the excess hydrostatic pressure build up in the soil mass due to the seepage of drain water at the higher reaches of the slope (Natarajan et al. 1984). In order to dissipate the excess hydrostatic pressure from the soil mass overlying the bed rock, the subsurface drainage technique with horizontal drains in combination with vegetative turf has been implemented as appropriate remedial measures to control the landslides (Natarajan et al. 1984). The same technique needs to be implemented in other locations in Nilgiris.
3. In addition to the sub surface drainage system some of the additional techniques including internal slope reinforcement consist of soil nails and stabilizing piles have to be explored. Slope failure due to vertical cut can be controlled by adopting nailing technique.
4. The sliding mass above the failure surface can be strengthened by placing passive piles embedded into sufficient depth in the stable layer below. The loads can be transferred to the more stable underlying layers and the soil movements can be resisted by piles which act as a barrier (Kourkoulis et al. 2011).

2.7.2.5 Lessons Learnt

1. The immediate triggering factor for the landslide at many locations was heavy intense rainfall, there were several causal factors like excavation of slope at toe, vertical cutting, loading at crest, defective maintenance of surface drainage systems and extensive anthropogenic interference.
2. Due to lack of proper subsurface drainage system, pore water pressure played a major role in initiating the landslide events.
3. Detailed geotechnical investigation is urgently required to suggest suitable site specific remedial measures.

2.7.2.6 References

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2.8 MAHARASHTRA

Maharashtra is a multi-disaster prone State. It is vulnerable to natural hazards like floods, cyclones, earthquakes, landslides etc. as well as manmade hazards like fire, building collapses etc. In Maharashtra, often landslides are triggered by heavy rains in the Western Ghats. Major landslide have

occurred in monsoon seasons due to anthropogenic development along the landslide prone regions. Landslide primarily results in loss of life and property, but has more importantly led to secondary and tertiary impacts.

The Konkan region – districts of Raigad, Ratnagiri and Sindhudurg and parts of Thane and Pune area are vulnerable to landslides. The foothills of the Sahyadris are dotted with many small and big villages all along the Konkan region which are vulnerable to landslides.

On 30 July 2014, a landslide occurred in the village of Malin in the Ambegaon taluka of the Pune district. It occurred because of heavy rainfall and killed more than 150 people.

On and from 25 July, 2005 incessant rains triggered massive landslides in Jui, Rohan, Dasgaon and Kondivate village in Mahad taluka of Raigad district and claimed more than 100 people and severely affected four villages.

A landslide that occurred in Ghatkopar suburbs of Mumbai, in July 2000 following heavy rainfall killed 67 people and injured many.

In a tragic landslide accident in Sakinaka on July 26, 2005, Mumbai, more than 74 people were killed and a large number of tin sheds destroyed when mud and boulders came down from nearby hillsides. (www.merinews.com/article/rain-causes-landslide-in-mumbai-)

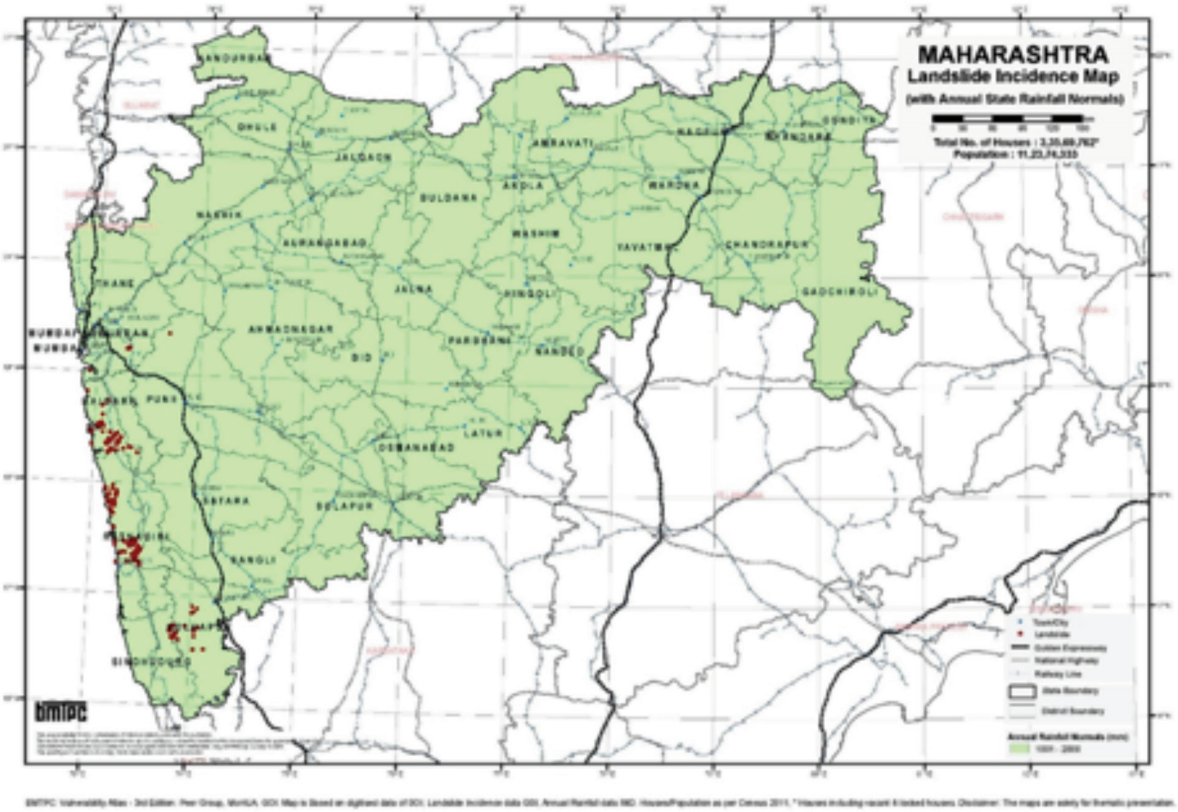


Figure-117: Vulnerability Atlas of Maharashtra (Source: BMTPC, 3rd Edition)

2.8.1 MALIN LANDSLIDE

2.8.1.1 Introduction

On 30 July 2014, a landslide occurred in the village of Malin in the Ambegaon taluka of the Pune district in Maharashtra, India. The landslide, which hit early in the morning while residents were asleep, was believed to have been caused by a burst of heavy rainfall.

2.8.1.2 Natural Causes of Landslides

1. The landslides were caused by heavy rainfall that had begun the previous day, with the village receiving 10.8 cm (4 in) of rain on 29 July and the downpour continuing throughout the following day.
2. The environmental destruction that resulted in the landslide is believed to have more than one cause.
3. Lowering of water table in the last few years and sudden rise observed due to the heavy rainfall.

2.8.1.3 Artificial Causes of Landslides

1. Deforestation in the area was cited as a cause contributing to the landslide.
2. Changing agricultural practices that the villagers had recently shifted from cultivation of rice and finger millet to wheat, which required levelling of steep areas, which contributed to instability of the hills.
3. The construction of the nearby Dimbhe Dam ten years ago was considered as a possible reason.
4. The instability of the hillsides was due to the construction activities, which are often done without careful analysis of environmental consequences.



Figure-118: Havoc due to rainfall triggered landslide (Source: https://www.thehindubusinessline.com/opinion/2014-malin-landslide-a-manmade-calamity/article32232138.ece)

2.8.1.4 Impact

This Landslide was declared as a National Disaster as it claimed roughly 155 lives. Mound of mud and debris that came down from a nearby hillock, swallowed up almost the entire tribal village of around 50 families. Due to the remoteness of the village, the tragedy came to light only when the driver of the first state transport bus reached the village a little after 7.30 am to find it uprooted. A huge loss of property and assets were observed after the disaster along with loss of infrastructure, lifeline facilities farmland. Loss in productivity of agricultural or forest lands due to being buried by debris. Reduced property values due to unwillingness of people to purchase disaster prone land. Loss of revenue due to loss of productivity, transport breakdown etc. Increased cost due to investments in preventing or mitigating future landslide damage. Loss of human productivity due to death and injury. Reduction in quality of life due to the deaths of family members and the destruction of personal belongings, which had a great sentimental value. Disaster had a profound impact on people's emotional wellbeing affecting their feelings, thoughts, actions and relationships.



Figure-119: Post-landslide scenario of Malin Village (Source: https://www.swadeshnews.in/national/pune-village-devastated-by-massive-landslide-at-least-10-dead-150-feared-trapped-see-pics)



Figure-120: The debris pile at the foot of the slope appears to be exceptionally wet near Malin Village (Source: https://www.swadeshnews.in/national/pune-village-devastated-by-massive-landslide-at-least-10-dead-150-feared-trapped-see-pics)

2.8.1.5 Actions Taken

1. Emergency services, including 378 personnel of the National Disaster Response Force, were mobilized to the area and 8 victims had been rescued from the landslide prior to the evening of 30 July.
2. As of 31 July, 22 people had been rescued alive from the landslide.
3. On 4^{t} August, the survivors of the landslide were ordered by the district administration to move out of Malin.
4. Apart from the Security Forces, members of voluntary organizations and locals also helped in rescue operations.
5. On 7 August, rescue operations officially drew to a close, with the final death toll estimate resting at 155.
6. A memorial with the names of men, women and children who died has been erected by the State Forest Department.
7. In addition, trees bearing the names of the deceased have been planted to make the lifeless slope look green again.

2.8.1.6 Recommendations

1. Surface water should be diverted away from the landslide-prone region by channeling water in a lined drainage ditch or sewer pipe to the base of the slope. The water should be diverted in such a way as to avoid triggering a landslide adjacent to the site. Surface water should not be allowed to pond on the landslider one slope (1997 Umbria-Marche earthquake (Italy)).
2. Removing the soil and rock at the head of the landslide decreases the driving pressure and can slow or stop a landslide. Additional soil and rock above the landslide will need to be removed to prevent a new landslide from forming upslope. Flattening the slope angle at the top of the hill can help stabilize landslide-prone slopes.
3. If the toe of the landslide is at the base of the slope, fill can be placed over the toe and along the base of the slope. The fill increases the resisting forces along the failure surface in the toe area. This, in turn, blocks the material in the head from moving toward the toe. However, if the toe is higher on the slope, adding fill would overload the soil and rock below the toe, thus causing a landslide to form downslope of the fill.
4. Piles are metal beams that are either driven into the soil or placed in drill holes. Properly placed piles should extend into a competent rock layer below the landslide. Wooden beams and telephone poles are not recommended for use as piles because they lack strength and can rot. Retaining walls can be constructed by adding lagging (metal, concrete, or wooden beams) horizontally between the piles. Such walls can be further strengthened by adding tiebacks and buttressing beams. Tiebacks are long rods that attach to the piles and to a competent rock layer below the ground surface. Buttressing beams are placed at an angle downslope of the piles to prevent the piles from toppling or tilting. Retaining walls also are constructed of concrete, cinder blocks, rock, railroad ties, or logs, but these may not be strong enough to resist landslide movement and could topple (Atkinson P M and Massari R 1998).

5. Landslide-prone soil and rock can be removed and replaced with stronger materials, such as silty or sandy soils. Because weathering of shales can form landslide-prone soils, the removal and replacement procedure must include measures to prevent continued weathering of the remaining rock. Landslide material should never be pushed back up the slope. This will simply lead to continued motion of the landslide (Baeza C and Corominas J 2001).
6. Trees, grasses and vegetation can minimize the amount of water infiltrating into the soil, slow the erosion caused by surface-water flow and remove water from the soil. Although vegetation alone cannot prevent or stop a landslide, removal of vegetation from a landslide-prone slope may initiate a landslide. (Baeza C and Corominas J 2001).

2.8.1.7 Lessons learnt

1. Deforestation, cultivation pattern, constructional activities etc. were the main cause of the disaster.
2. Very high continuous rainfall was a current effect for the disaster and created a mud flow towards the Malin village.
3. Traditionally, rice, sag, finger millet and pawata are the main crops cultivated in the area of Ambegaon. But in last few years, they change the cropping pattern. They started cultivation of wheat and many more different crops. These crops demanded the change in cultivation process. According to requirement, they started leveling steep areas and flattening the hill tops. Cultivation of these crops also required more water which leads to saturating the slope. This type of major activity on the surface of earth on hill slope without knowing the result always occurred major disasters.
4. The reason behind this many human activities that are going on for a long time. When it is seen in large prospective, then it is observed that it is not a natural disaster.

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2.8.2 MUMBAI LANDSLIDE-2000

2.8.2.1 Introduction

The 2000 Mumbai landslide was a landslide that occurred in Ghatkopar, a suburban neighbourhood located in Mumbai, India on 12 July 2000. The landslide was caused by land erosion, following heavy rains and subsequent flooding that coincided with a high tide in the Arabian Sea. According to meteorologists, more than three hundred and fifty millimeters of rain fell on the suburbs of Mumbai in the twenty-four-hour period before the landslide.



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The passengers of Sabyadri Express which was stuck in the flooded waters at Chanabhatti are being evacuated by nearby residents using a ladder on Wednesday. Anil Bhartia

Figure-121: Archived report of landslide in Mumbai, 2000 (Source: https://www.freepressjournal.in/cmcm/on-this-day-in-history-july-12-2000-landslide-caused-by-heavy-rains-kills-67-people-in-mumbais-ghatkopar-area)

2.8.2.2 Impact

As many as 67 people died and many got injured. Many people were forced to stay indoors because of the rain and were caught in the landslide which came without warning. The victims were from a community of slum settlers who inhabit about 200 small hovels on the Balbati hillside in Ghatkopar district, overlooking eastern Bombay. Train services within Bombay and from other parts of India were badly affected.

2.8.2.3 Actions Taken

1. Army and naval diving teams were called in to help authorities in carrying out rescue operations.
2. More than 150 fire brigade personnel continued search and rescue operations. Looking for survivors in the mass of mud that came down on 100 hutments following heavy rains.
3. The Army was called in to assist the civic authorities here in carrying out search and rescue operations at the Chiragnagar-Azadnagar locality at Ghatkopar in the eastern suburbs.
4. The Navy pressed three squads in flooded areas of Kurla, Santacruz and Andheri with life boats.
5. The quick response of the fire brigade saved 54 lives of whom 21 were undergone treatment at the Rajawadi Hospital at Ghatkopar and the Lokmanya Tilak Municipalised General Hospital at Sion. Twenty three were discharged after treatment.
6. Local electricity officials turned off the supply in some areas, as the water level rose dangerously close to transponders.
7. In the years since the 2000 Mumbai landslide, Mumbai has been determined by the Municipal Corporation Building to contain 327 areas that are in danger of landslides, including 49 in the city and 278 in the suburbs. Since this revelation, thousands of huts have been relocated or reinforced to protect the inhabitants from landslides.
8. The government announced ex-gratia of Rs 25,000 to the next of the kin of those killed in the landslide and Rs 10,000 to every injured.



Figure-122: Several people were killed after a wall collapsed on some shanties in Chembur's Bharat Nagar area due to a landslide in Mumbai. (Source: https://www.hindustantimes.com/cities/mumbai-news/mumbai-rains-updates-landslide-vikhroli-chembur-bharat-nagar-22-dead-several-injured-after-heavy-downpours-101626574611191.html)

2.8.2.4 Recommendations

1. Landslides in a coastal city like Mumbai and that too in residential areas are entirely due to anthropogenic activities. "Slopes of these hills in Mumbai are perfectly stable. No landslide will occur if they are not disturbed,", "but stone quarries are opened up on these slopes at many places, cutting them into vertical faces." This destabalises the hill slopes, removing the basal support for the rock blocks that occur above. Many people who had built hutments below the hill on the abandoned quarry floor faced the disastrous landslides.
2. Many measures to stabilise the hill slopes include driving rock bolts, construction of retaining walls below the slopes, spraying cement mixture over the hill slopes, putting steel wire nets over the slopes and supporting loose boulders with brackets.
3. Prohibiting quarrying altogether in residential areas and permitting such activities in remote areas where sufficient rock is available.
4. One important appeal to the authorities was to declare at least 20 meters around the hills in Mumbai as landslide-prone areas and see that no hutments come up within this zone.
5. The Slum Improvement Board of the Maharashtra Housing and Areas Development Authority has been taking preventive measures like constructing retaining walls over the years.

2.8.2.5 Lessons Learnt

1. In landslides prone areas all development activities should be carried out only after proper planning and protective measures
2. Natural drainage system should be protected while making roads, cannels, railway tracks and other developmental works in landslide vulnerable areas.
3. It should be mandatory not to develop settlements in landslide prone hill stations, sloppy areas and newly constructed road sides susceptible to landslide risk etc.
4. In advance relocate the infrastructures and settlements in the risk zones.
5. Set up temporary shelters for evacuees.
6. Make provision for essential services like food, clothing, blankets/bedding, drinking water, light and essential medicines.
7. Deployment of First Aid team and medicines.
8. Arrange transportation for patients to take them to hospitals in case of serious condition.
9. Maintain law and order in the affected sites.
10. Take special care of old persons, pregnant women, disables and children

2.8.2.6 References

1. https://www.rediff.com/news/2005/aug/03rain.html
2. http://news.bbc.co.uk/2/hi/south_asia/831267.stm
3. https://www.tribuneindia.com/2000/20000714/main2.htm
4. https://rfd.maharashtra.gov.in/sites/default/files/DM%20Plan%20final_State.pdf

2.8.3 MUMBAI LANDSLIDE-2021

2.8.3.1 Introduction

The 2021 Mumbai landslide was a series of landslides that occurred in Chembur and Vikhroli, the suburban neighbourhood located in Mumbai, India on July 18, 2021.

2.8.3.2 Impact

At least thirty-two people were killed and several others injured after they were trapped under houses that collapsed due to landslides caused by heavy rains. The Western Railway and Central Railway briefly suspended suburban train services in Mumbai after the heavy rains and many long distance trains were terminated or regulated at various stations (Source: The Tribune 18 July 2021) landslides following the incessant overnight rain in Mumbai, which caused severe water-logging and disruption of suburban train services and vehicular traffic.



Figure-123: People use their mobile phones to take pictures of a collapsed building following rains in Mumbai, India, July 23, 2021. (Source: REUTERS/Stringer)

The landslides following the incessant overnight rain in Mumbai, which caused severe water-logging and disruption of suburban train services and vehicular traffic. Several parts recorded unprecedented rain in the past 24 hours, with Mahabaleshwar hill station in Satara notching 480 mm, the highest in 45 years and Matheran recording 330 mm rain, while many other areas saw rain in excess of 200 mm, created panic.

Thousands of trucks were stuck on a national highway linking Mumbai with the southern technology hub of Bengaluru, with the road submerged in some places.



Figure-124:Post-landslide scenario in Mumbai
(Source: https://tribune.com.pk/story/2311842/at-least-112-dead-in-india-as-rains-trigger-floods-landslides)

2.8.3.3 Actions Taken

1. Dams and rivers were overflowing. Authorities were forced to release water from dams and, accordingly, they were moving people residing near the river banks to safer places.
2. The navy and army helped with rescue operations in coastal areas.
3. The Western Railway and Central Railway briefly suspended suburban train services in Mumbai after the heavy rains and many long distance trains were terminated or regulated at various stations.
4. The India Meteorological Department (IMD) issued a red alert for Mumbai in the backdrop of heavy rains. Alerts by the IMD are colour-coded from green to red. A 'green' alert stands for 'no warning': no action needs to be taken by the authorities and the forecast is of light to moderate rain. A 'red' alert stands for "warning" and asks authorities to "take action". An 'orange' alert indicates that the authorities are expected to "be prepared".
5. Rescuers were seen using their hands to dig up the ground and retrieve bodies, local television showed and authorities said more victims could be trapped inside the debris. Rescuers were also shown carrying the injured through narrow lanes on makeshift stretchers.
6. The Maharashtra government announced an ex-gratia of Rs 5 lakh each to the kin of people, who have died in landslides triggered by heavy rains in different parts of the state. The injured will be treated in hospitals at the state's expense.



Figure-125: A search and rescue operation on after a wall collapsed on some shanties in the Chemburs Bharat Nagar area due to a landslide, in Mumbai, on July 18th, 2021. (Source: https://www.tribuneindia.com/news/nation/25-die-as-heavy-rain-triggers-landslides-in-mumbai-rail-road-traffic-hit-284979?ref=epaper)



Figure-126: Rescue teams carrying a body from a site devastated by a landslide. (Source: https://nypost.com/2021/07/18/mumbai-landslides-kill-at-least-25/)

2.8.3.4 Recommendations

- As the primary factor behind frequent flooding, is frenetic pace of construction in the city. Mumbai is in a constant state of expansion, laterally and vertically and large-scale construction activity is a constant for the city.
- Livelihood restoration support to marginal farmers and the families having lost their family members with agricultural inputs to start micro-scale business.
- Community based disaster preparedness.
- Developing a series of new insurance instruments to provide risk coverage to multiple categories of households and enterprises in cities and incentives for public-community-private partnerships to mitigate risk.
- The government must take ownership of the hill conservation and develop it as a nature project for education and botanical research with limited hours of eco-tourism

2.8.3.5 Lessons Learnt

1. The old foundations of poorly built structures often buckle under days of non-stop rain.
2. Removal of natural vegetation, cutting of slopes, quarrying and road building are taking a huge till across the upland areas of India.
3. Climate change is going to exacerbate these problems at pace, as will continued damage to slopes. If we are to reduce these disasters, we need to manage the slopes properly.

2.8.3.6 References

1. https://www.reuters.com/world/india/landslides-kill-least-15-mumbai-after-heavy-rains-2021-07-18/.
2. https://www.dw.com/en/india-at-least-25-dead-in-mumbai-landslide-caused-by-heavy-rain/a-58305156
3. https://www.theguardian.com/world/2021/jul/19/deaths-mumbai-monsoon-rains-landslide-india

2.9 MEGHALAYA

The State of Meghalaya is prone to natural hazards such as earthquakes, floods, landslides and cyclones, which affect a large number of the population who are residing in the vulnerable areas of the state. Meghalaya being a hilly terrain is prone to landslides. Every year a number of landslides have been reported from various localities. These cause a lot of miseries to public, resulting in loss of lives and properties, disruption of communication network, besides causing economic burden on the society. Landslide is primarily attributed to high slope, immature geology, neo-tectonic activity, heavy rainfall, unplanned and improper land use practice in the State. Landslides generally occur during heavy rains, that is during the months of June to October in Meghalaya.



Figure-127: Landslide incidence map of Meghalaya (Source: BMTPC)

Southern part of Meghalaya is more susceptible to Landslides than the Northern Part. National Highways like Bajengdoba-Tura-Dalu, Damra–Siju-Baghmara, Guwahati – Shillong- Tamabil and Shillong- Jowai-Badarpur are prone to landslides. Landslide occurred frequently at Sonapur on Shillong- Jowai- Badarpur Road, but now the problem has been mitigated by constructing a tunnel for the vehicular traffic. Urban areas of Shillong and Tura, Jowai are also prone to landslides due to the faulty Construction of Houses and rapid Urbanization.

Table 12 Number of persons died due to Landslides in the Meghalaya State (Source: Revenue and Disaster Management, Govt of Meghalaya

Year	East Khasi Hills	West Khasi Hills	Ri-Bhoi	West Jaintia Hills	East Jaintia Hills	East Garo Hills	West Garo Hills	North Garo Hills	South Garo Hills	South West Khasi Hills	South West Garo Hills
	No. of persons died										
2005	---	---	---	---	---	---	---	---	---	---	---
2006	---	---	---	---	---	---	---	---	---	---	---
2007	4	---	---	---	---		---	---	---	---	---
2008	---	---	---		---	---	---	---	---	---	---
2009	---		---		---	---	---	---	---	---	---
2010	---	---	---	3	---	---	---	---	---	---	---
2011	---	---	---	---	---	---	---	---	---	---	---
2012	---	2	3		---	---	---	---	---	---	---
2013	---	---	---	---	---	---	---	---	---	---	---
2014	9	3	---	3	---			27	---	---	---
Total	13	5	3	6	---			27	---	---	---

2.9.1 EAST KHASI HILLS LANDSLIDE

2.9.1.1 Introduction

A landslide triggered by incessant rainfall in Meghalaya's East Khasi Hills district on September 22nd, 2020.



Figure-128: Meghalaya Landslide in east khasi hill district in meghalaya in 2020 (Source: https://indianexpress.com/article/north-east-india/meghalaya/meghalaya-rains-landslides-13-killed-5-missing-6617017/)

2.9.1.2 Impact

At least thirteen people were killed in rainfall-related incidents across Meghalaya.

According to a district-wise cumulative report issued by the State Disaster Management Authority, five people remain missing while a total of 985 people in 37 villages across East Khasi Hills, West Khasi Hills and Ri Bhoi districts have been affected because of the continuous downpour over the past week. Among the victims, are two women cricketers who were killed in a landslide which struck their homes in lower Lumparing Dhobi Ghat, situated in the Laban area of East Khasi Hills district. Three others from the area went missing. Several bridges have collapsed and roads damaged in different parts of Meghalaya, as a result of landslides and flash floods. A wooden bridge at Dumnikura area in Meghalaya's South Garo Hills was washed away by flood waters. The bridge was located about 40 km from Baghmara between Tura-Baghmara connecting road.

Two workers engaged by the police in clearing the debris at their quarters in Shillong. A portion of the Riangdo-Bamil road, a PMGSY road at Mawshynrut-Thaiem and the Mawshynrut-Hahim road affecting traffic movement in West Khasi Hills district.

South Garo Hills was cut off from West Garo Hills after the Dumnikura timber bridge located on NH-62 directly connecting the two districts got washed away. Landslides have also destroyed several village roads and national highways across the state. NH 44E was partially damaged and debris has blocked the road leading to Nongstoin Civil Hospital in West Khasi Hills district.



Figure-129: Landslide buries several homes in Meghalaya (Source: https://www.indiatvnews.com/news/india/meghalaya-landslide-death-toll-several-homes-destroyed-652107)



Figure-130: Image from Kynshi area in West Khasi Hill district. (Source: State Disaster Management Authority)

2.9.1.3 Actions Taken

1. Rescue operations were carried out by local police and SDRF personnel.
2. The Regional Meteorological Department, Guwahati, had issued a red alert for Meghalaya, Arunachal Pradesh and Assam between September 24 and 25, predicting heavy to very heavy rainfall and thunderstorms in isolated places.
3. Landslides were reported from several areas across the state and PWD workers were pressed into services to clear the debris.
4. Efforts were made to connect Baghmara from Nengkhra-Siju-Karukol side, Chokpot-Siju side and the parallel road from Ramchenga/Dumnikura to Dalu.
5. Meghalaya government has announced immediate release of ex gratia amount of Rs 4 lakh each to next of kin.

2.9.1.4 Recommendations

1. As landslides mostly occur due to heavy precipitation, identify all stream runoff and clear blocked areas before the rainy season, to avoid blockade.
2. Maintain and protect both sides of the river and stream to avoid erosion and improve the channels for free flow of water.
3. Develop an inventory of the existing built environment in areas around existing landslides and in high hazard zones as per the landslides hazard Zone (LHZ) maps and along strategic road.
4. Monitoring of landslide prone areas either through an automated system or by preparation of hazard area maps and following up ground check on such vulnerable areas during monsoon or rainy season.
5. House site allotment should be considered only after careful consultation with Land Use Plan to avoid risk of landslides and land-sinking.
6. Laws should be enforced to regulate or prevent construction in vulnerable areas and ensure that any type of construction or developmental activities in high hazard areas be cleared only after appropriate remedial measures are in place.
7. Soil testing should be mandatory before permission is considered for any new construction.
8. Organize public awareness campaigns on warning and protective measures to be undertaken, importance of insurance and structural mitigation measures.

9. Conduct LHZ and prepare Landslide Incidences mapping. Paleoslide zones should be identified and mapped.

2.9.1.5 Lessons Learnt

1. Those in the affected area are advised to monitor local weather reports, anticipate transportation disruptions, avoid landslide-prone areas, confirm road conditions before setting out and adhere to local authorities' instructions.
2. Everyone should be aware of potential disasters and informed of protective and safety measures.
3. Extreme precipitation events (heavy rain storm, cloud burst) may have their own impacts on the fragile geomorphology of the Himalayan part of the Brahmaputra basin causing more widespread landslides and soil erosion.
4. Soils that have a low content of organic matter are more prone to droughts and landslides and are less productive for plant growth. It also deposits large amount of sediments which reduce the plant growth for the livestock.

2.9.1.6 References

1. https://www.indiatoday.in/india/story/meghalaya-two-people-killed-massive-landslide-in-shillong-1725130-2020-09-24
2. https://indianexpress.com/article/north-east-india/meghalaya/meghalaya-rains-landslides-13-killed-5-missing-6617017/
3. https://www.indiatvnews.com/news/india/meghalaya-landslide-death-toll-several-homes-destroyed-652107
4. https://www.onmanorama.com/news/india/2020/09/26/national-level-woman-cricketer-killed-missing-landslides-meghalaya.html

2.10 MIZORAM

The terrain of Mizoram has an immature topography, with several longitudinal valleys containing series of small and flat hummocks, mostly anticlinal, and narrow synclinal valleys with series of topographic highs. These cause a lot of miseries to public, resulting in loss of life and property, disruption of communication network and also cause economic burden on the society. This is primarily attributed to high slope, immature geology, neo-tectonic activity, heavy rainfall, unplanned and improper land use practice in the State. Landslide incidents are more prominent during the rainy/monsoon season as the soil structure gets softened by heavy and continuous downpour, especially in areas having high degree of slope. There can be many factors that make an area vulnerable to landslides, both induced by human activities as well as inherent natural composition of the soil. However, in most cases the former factor is a contributing factor, especially in areas where development activities are higher and drainage facilities are neglected. As per records of Disaster Management & Rehabilitation (DM&R) Dept., incidents of landslides from 2013 to 2019 are prominent in all districts of the State where it affects not only physical infrastructure but also human life, domestic animals and agricultural production.

Table 13 History of Damages causedd by Natural Calamities in Mizoram (2013-2019)
(Source: DM & R Department Records)

Landslide	Human Casualties		House Damaged		
	Deaths	Injuries	Fully	Severly	Partially
	68	37	600	313	659

Based on the Landslide Hazard Zonation study in the whole area, the State is classified into five zones in terms landslide vulnerability, these are:-

Very High Hazard Zone: This zone is highly unstable and is at a constant threat of landslides, especially during and after an intense spell of rain. This is because the area forms steep slopes with loose and unconsolidated materials. Besides, it includes areas located near faults and tectonically weak zones. It also includes areas where unplanned quarrying, road cutting and other human activities are extensively undertaken. The vegetation is generally scarce. The rocks exposed are characterized by numerous bedding and joint planes which facilitate the chance of sliding down along the slope. Therefore, it is best to avoid this zone as far as possible except if unavoidable. This zone constitutes an area of 1822.39 sq km and forms 8.65 per cent of the total study area.

High Hazard Zone: It includes areas where the probability of sliding debris is at a high risk due to weathered rock and soil debris covering steep slopes which when disturbed are prone to landslides. Most of the pre-existing landslides fall within this category. Besides, this zone comprises areas where the slope aspect and dip direction of the rocks, which are usually very steep, (about 45 degrees or more) are parallel to each other. This rendered them susceptible to sliding along the slope. Several lineaments, fractured zones and fault planes also traverse the high hazard zone. Areas which experience constant erosion by streams because of the soft nature of the lithology and loose overlying burden fall under this class. Vegetation is generally either absent or sparse. Owing to the above reasons, this zone is also geologically unstable and should be avoided. This zone occupies a fairly large area – about 4263.58 sq km which is 20.22 per cent of the total study area. Moderate Hazard Zone: This zone is generally stable, though it may contain some unstable zones in some areas. Moreover, seismic activity and continuous heavy rainfall may reduce its stability. Though this zone may include areas such as cliffs that have steep slopes (more than 45 degree), the orientation of the rock bed and absence of overlying loose debris and human activity make them less hazardous. In general, this zone comprises areas that have moderately dense vegetation, moderate slope angle and relatively compact and hard rocks. This zone is predominantly high in terms of areal extent. It spreads over an area of about 8903.04 sq km and occupies 42.24 per cent of the total study area.

Low Hazard Zone: This includes areas where the combination of various controlling parameters is generally unlikely to adversely influence the slope stability. In other words, this zone comprises areas where the chance of slope failure is low or unlikely to occur. Vegetation is relatively dense, though some areas may not have vegetative cover. Although some of the areas may be covered with soft and unconsolidated sediments, the slope angles are generally low, about 30 degrees or below. This zone extends over an area of about 5011.33 sq km and forms 23.77 per cent of the total area.

Very Low Hazard Zone: This zone generally comprises mainly vegetative areas and is located away from human settlement. As such, it is assumed to be free from present and future landslide hazard. The dip and slope angles of the rocks are fairly low. Although the lithology may comprise soft rocks

and overlying soil debris in some areas, the chance of slope failure is minimized by low slope angle and vegetation present within its vicinity. This zone covers an area of about 968.67 sq km and forms 4.60 per cent of the total study area. Apart from the various hazard classes, some area is covered by water bodies which are not included in the hazard classes and it covers an area of 111.96 sq km which is 0.53 per cent of the total study area.

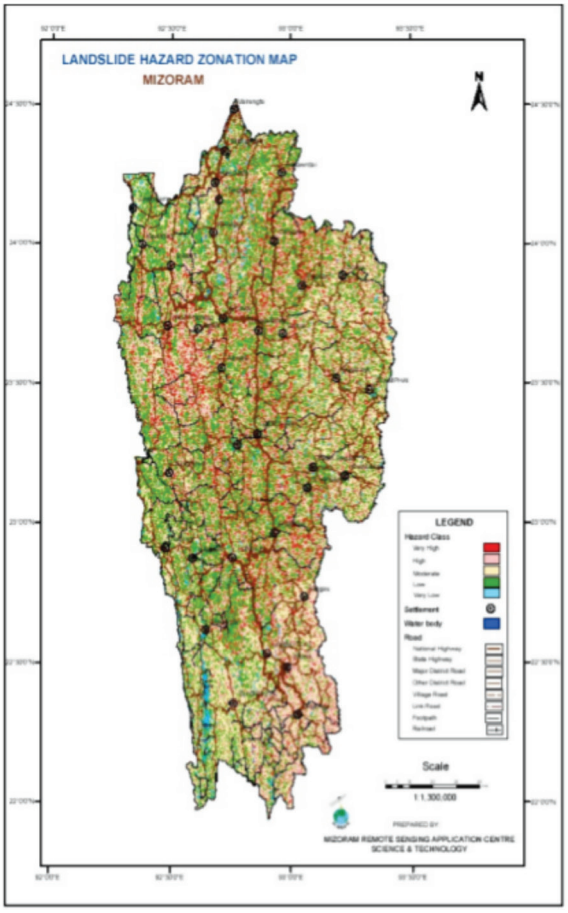


Figure-131: Landslide hazard Zonation Map (Source : Mizoram SDMP 2020)

- Out of 23 Sub-divisional headquarters, 3 of them fall under high landslide hazard zone. 9 Sub-division headquarters come under moderate hazard zone and 10 Sub-division headquarters are within low hazard zone.
- There are 25 hospitals within the State out of which 12 hospitals are within moderate class of landslide hazard zonation. The rest (i.e.13 hospitals) falls under low hazard zone.
- There are 17 important bridges in the State and all of them fall within low landslide hazard zone.
- Lengpui airport is within low class of landslide hazard zonation.
- Pumping stations of Greater Aizawl Water Supply Scheme-I and Greater Lunglei Water Supply Scheme fall within moderate landslide hazard zone.
- Pumping station of Greater Aizawl Water Supply Scheme-II falls under low landslide hazard zone.

- Within Mizoram, the total length of National Highway is 861.12 km out of which 7.89% falls in very high landslide hazard zone. 17.42% is under high hazard zone and 33.49% falls under moderate class. 43.18% is under Low hazard zone. The rest which is 7.16% falls under very low landslide hazard zone.
- The total length of State highway is 728.84 km out of which 10.55% falls in very high landslide hazard zone. 11.42% is under high hazard zone and 37.55% goes to moderate class, 33.13% is under Low hazard zone. The rest which is 7.59% is in very low landslide hazard zone.
- The total length of district roads is 891.05 km out of which 5.00% falls in very high landslide hazard zone. 13.80% is under high hazard zone and 44.97% goes to moderate class, 31.40% is under Low hazard zone. The rest which is 5.26% is in very low landslide hazard zone.
- The total length of village roads is 1214.37 km out of which 3.90% falls in very high landslide hazard zone. 16.90% is under high hazard zone and 42.56% goes to moderate class, 28.98% is under Low hazard zone. The rest which is 7.79% is in very low landslide hazard zone.

Landslide is the most common natural hazard within the State and it may affect the whole population at one time or another. Landslide prone districts within the State are Aizawl district which is having a total population of 4,04,054 with 34.99% of district area in Very high & high landslide hazard zones, Saiha district having a population of 56,366 with 34.34% of district area in Very high & high landslide hazard zones and followed by Serchhip district which is having a population of 64,875 with 30.65% of district area in Very high & high landslide hazard zones. Mamit and Lunglei districts having population of 85,757 with 29.64% of district area in Very high & high landslide hazard zones and 1,54,094 with 28.34% of district area in Very high & high landslide hazard zones respectively. Other districts like Kolasib (population of 83,054 with 26.95% of district area in Very high & high landslide hazard zones), Lawngtlai (population of 1,17,444 with 26.11% of district area in Very high & high landslide hazard zones) and Champhai (population of 1,25,370 with 22.99% of district area in Very high & high landslide hazard zones) have lower risk in term of landslide hazard.

Table 14 Some of the Major landslides recorded in Mizoram (Mizoram SDMP 2020)

Date	Disaster	Remarks
1929	Cloudburst & Landslide	Known as "Minpui kum" in the local dialect, it rained incessantly for 10 day between 1st to 10th June resulting in numerous landslide in the whole of the state
July 11th, 1986	Landslide/rock slide	Landslide/rock slide occurs at South Hlimen, killed 4 persons
1991	Landslide/slump	Sihpui & Ramthar area, Aizawl. 70 houses were demolished.
Aug 9th, 1992	Rockslide	Stone quarry collapsed at South Hlimen damaged 17 houses, killed 66 persons. Recurred in 2005.

1992	Recurrent sinking area	Hunthar, Aizawl. Recurrent sinking caused damage to the NH-54 and 17 houses damaged, recur in 1993, 1995, 1996, 1997, 2001, 2003, 2005, 2006, 2007, 2008, 2010, 2011
May, 1995	Cloudburst & Landslide	Cloudburst in Lawngtlai & Saiha town area on May 16 & 17, totalling 360 mm of rain. Human casualty - 34, injured-6, fully damaged house- 270, severely damaged houses- 467
2004	Landslide/ Subsidence	45 buildings and 55 families were affected at Ngopa village
2004-2005	Landslide/slump	Armed veng, Aizawl. Affected more than 100 houses, 25 houses were vacated
2005 Landslide	Landslide /slump	Chandmari west. 30 houses vacated
Sept, 2007	Landslide	Many landslides throughout Mamit District blocking NH-44A for 13 day
2010	Land subsidence	Mamit Town – 65 houses destroyed/dismantled. Ngopa town – 10 houses destroyed/dismantled
July 21st, 2012	Rock fall	Rock fall at stone quarry, Keifang swept a bus down a ravine killing 19 and injured 16 persons
August 8th, 2012	Landslide	Landslide at Aizawl-Tuirial road swept a Taxi down a cliff killing 3 and injured 3 persons
August 11th, 2012	Land subsidence	Subsidence started back in 2004 at Ramhlun Sports Complex and Ramhlun Vengthar areas, 7 houses were damaged and 56 families were evacuated.
May 11th, 2013	Landslide	Laipuitlang, Aizawl. Destroyed 12 houses, killed 17 and injured 9 persons.
July 2013	Land subsidence	Recurrence at Ramhlun Sports Complex and Ramhlun Vengthar areas, 15 houses damaged and a number of families evacuated.
11th June, 2018	Landslide	Hnahthial, Kanan veng totally damaged NH 54, 250 metre (approx.)
12th June, 2018	Recurrent Land subsidence	Hunthar, Aizawl 29 families evacuated during 2015-2019

19th July, 2019	Landslide	Aizawl to Champhai Road NH – 6 near Haidai river, totally damaged
July, 2019	Landslide/sinking	College veng, Lunglei, 12 families were evacuated and 7 residential houses are dismantled
19th and 25th July, 2019	Landslide	Road (NH 54) blockade at Mualkhang area and Bawngkawn area respectively
2nd July, 2019	Landslide, Collapsed building	3 Blocks of BSUP building at Durtlang locality collapsed due to landslide which claimed 3 lives and injuring 11 persons. 138 families were evacuated

2.10.1 AIZAWL LANDSLIDE

Table 15 Matrix of Past Disasters In The Aizawl District (Aizawl District Disaster Management Plan 2017)

Type of Disaster	Year	No. of villages affected	Houses damaged	Animals perished	Human Casualty		Financial assistance
					Lives lost	Injury	
Landslide	2012-2013	Not Specified	85	4	23	16	Rs 50,50,535/-
	2013-2014	165	86	Nil	19	11	Rs 17,27,700/-
	2014-2015	165	88	1	2	Nil	Rs 42,79,600/-
	2015-2016	13	73	1	1	Nil	Rs 51,50,900/-
	2016-2017	43	161	4	11	1	Rs. 2,85,55,470/-

2.10.1.1 Introduction

At the early Saturday morning on 11th May 2013, a rockslide occurred at the slope of Laipuitlang, border of Ramhlun Venglai municipal local council area of Aizawl, Mizoram, India. The incidence situated near PWD Side Office (Mechanical Sub-Division), Aizawl, located between 23440 6000 N and 92430 1600 S at 1,120 m above mean sea level.

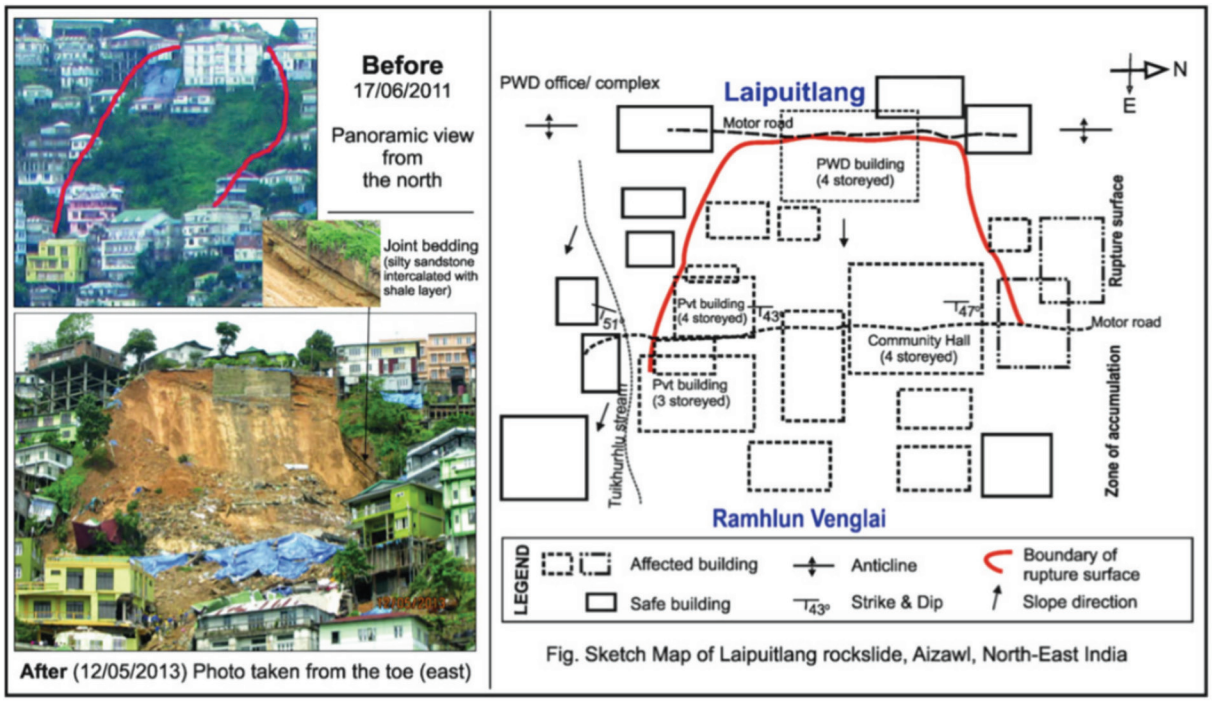


Figure-132: Pre-event photo and after rockslide; sketch map showing general geology and settlements (Source: Laldinpuia and Singh 2014)

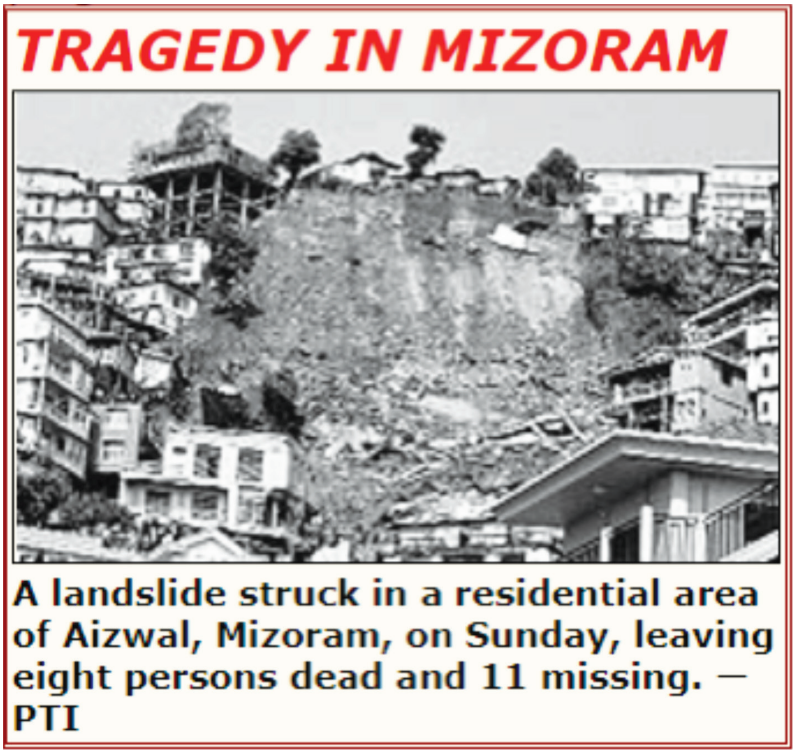


Figure-133: Archival newspaper snapshot of Mizoram tragedy (Source: https://www.tribuneindia.com/2013/20130513/nation.html)

2.10.1.2 Impact

1. Seventeen persons were found dead under the thick debris and 8 persons were rescued by the State Disaster Search & Rescue Team.
2. The rockslide badly affected and destroyed 15 houses (seven RCC buildings and eight Assam Type buildings) including community hall and an evacuated four storeyed RCC building of Public Works Department (PWD), Government of Mizoram.
3. The area had experienced huge rockslide in 1957 and 1968 due to cutting of rock bed for one-time quarrying. The surrounding localities also experienced an anthropogenic induced landslide. On the 5 May of 2002, rockslide at Ramhlun affected one person died and concrete building collapse at the toe of the same dip direction after unsafe cutting of the rock bed and heavy rainfall.
4. In 2007, on 25 November, rockslide affected Ramhlun South area after unsafe cutting of the rock bed for building construction. This rock bed was successfully mitigated using rock bolt in 2009.



Figure-134: Photograph showing joint bedding, tension cracks and zone of accumulation (Source : Laldinpuia and Singh 2014)



Figure-135: Effects of rockslide (Laldinpuia and Singh 2014)

2.10.1.3 Actions Taken

1. The tension cracks first observed at the walls of building and slope face on June 2010. On September 2012, tension cracks were observed at the rock bed and soil, retaining walls and PWD RCC building which occurred at the crown along Laipuitlang road. Geologists' from the Directorate of Geology & Mineral Resources (Government of Mizoram) strongly suggested that PWD building was to be vacated and to be demolished as preventive measures. But, before taking action for demolished, the 11 May 2013 rockslide destroyed the building and also observed as that this increased the catastrophic disaster for settlements at the toe region.
2. Security personnel and volunteers searched the debris for missing people.

2.10.1.4 Recommendations

The 11th May 2013 Laipuitlang rockslide is one of the disastrous catastrophic events in Mizoram. The occurrence influenced strengthening and improvement of Disaster Management in the State.

Considering regional and local geology, vis-a-vis rock/rockmass condition of the site along with the fact that it was a sloping ground, proper studies on stability and safety might not have undertaken while planning for a big four-storeyed RCC building, and if these were undertaken, it appears that these were compromised.

2.10.1.5 Lessons Learnt

The state of Mizoram is vulnerable to various natural hazards. Knowing these, the state government takes various mitigation, prevention and preparedness measure and also undertakes different response and rehabilitation activities. Capacity building activities and mass awareness activities were also taken up. But with limited man and material resources, lack of coordination among various agencies, economy and ignorance of the people like anthropogenic activities resulting in landslide, use of substandard building materials, settlement in vulnerable areas etc., satisfactory achievement is impracticable.

2.10.1.6 References

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2.11 NAGALAND

Nagaland is a multi hazard prone State in the North Eastern Region of India. It comes under the seismic zone IV/V and hence, falls under a very high damage risk zone. The general area is low-lying hills which are prone to landslides due to unstable rock materials, especially during the rainy season which lasts from May to September. Nagaland is connected to the rest of the country by a lone airport and railhead, both at Dimapur and National Highway 39 and National Highway 37. The National Highways continue to remain an uncertain source of poor connectivity as it is beset with problems of landslides every monsoon. In the face of a disaster, accessibility to and within the State remains a mammoth logistic hurdle.

Much of the state is very hilly comprising of steep slopes and high relief. Nagaland is predominantly made up of shale and sandstones in various combinations. Most of the rocks, particularly the shale‘s are sheared, fractured, crumpled and weathered to various extents. They are normally saturated with water which leads to the building up of high pore-water pressure thereby causing the loss of shearing strength and collapse of the soil structure. Sandstones, particularly those of the Tipam Group in the Belt of Schuppen along the western fringe of the state are weak due to poor cementation and compaction. Repeated thrusting and faulting have further weakened the rocks. Such sandstone areas are known for rock falls and debris slides.

In Nagaland, faulty land use practices such as jhum cultivation and heavy constructions are landslide initiators. Water stored in paddy fields induces instability because of great porewater pressure generated on the soils due to retention of excess water for the paddy plants. Another important factors causing landslides in Nagaland is faulty road construction methods. Landslides occur because road construction design and slope stabilization structures are very poor. Besides natural Environmental factors, excavation for rocks and slope modification for agriculture have made many parts of our environment susceptible to mass wasting.

2.11.1 PAST DISASTERS IN NAGALAND

Landslide is a major disaster that keeps affecting Nagaland specially in Monsoon, when heavy down pour is experienced all over Nagaland. It is a fact that properties worth lakhs and crores of rupees have been carried away by these Landslides. Some of the major Landslide Disasters that Nagaland has faced are:

2.11.1.1 Landslide of August-2001

Dimapur area experienced a cloud burst which lasted almost for one hour. This gave rise to so many landslides in that area, particularly the Paglapahar region which experienced the heavy down pour. In a stretch of just 4 kms on National Highway 39, seven major slides occurred which brought traffic to a standstill. In this incident 1 Tata Sumo was crushed where 3 people were killed and some injured.



Figure-136: Some of the houses damaged by the landslide at lower Chandmari area, Kohima town (Source: NSDMP)

2.11.1.2 Landslide of August-2003

The whole New Market colony in Kohima Town was affected by landslides. Many houses were razed to the ground and many more were made unfit for habitation. The road was affected very badly, that for a year it had to be abandoned. Property worth lakhs were destroyed by this slide.

2.11.1.3 Landslide of May-2005

The most tragic landslide that affected Nagaland in the recent past was the May 26, 2005. Landslide that occurred in Mokochung Town. In this pre dawn landslide, 14 people were buried alive, so many more injured and damage to property was extensive.

2.11.1.4 Landslide of August-2006

Wokha town was affected very badly by a landslide in August 2006. National Highway 61 was affected very badly. Extensive damage to property was reported.

2.11.1.5 Landslide of September-2006

Zunheboto Town was affected by a Major landslide. This resulted in extensive damage to property.

2.11.1.6 Landslide of October-2007

About 150 metres of National Highway 39 near Kiruphema went down almost 400 meters. This resulted in the complete blockade of the highway for 2 days.

2.11.7 MOKOKCHUNG TOWN LANDSLIDE

2.11.7.1 Introduction

The landslides occurred at Mokokchung town on 26 May 2005. The landslides were triggered by the heavy rains that lashed Mokokchung throughout the night.

2.11.7.2 Impact

- In this pre dawn landslide, 14 people were buried alive.
- Even as the people got buried in sand and mud and walls collapsed, there was little that the neighbours could do as the rains lashed the town throughout the night.
- It was only around 5 in the morning that the sky cleared a bit and people could go in for rescue operations, rushing to the spots.
- While most houses in the slide areas have been totally destroyed, communication and power remained intact.
- However, some of the roads leading to the National Highway-39 have been blocked.
- The slides occurred at Alongmeren, Tongdengtsuyong and IOC wards.

2.11.7.3 Actions Taken

1. The Civil Administration, police, CRPF, Assam Rifles and other NGOs and the citizens swarmed the slide areas and helped in the rescue work.
2. The State Govt has reportedly announced ex-gratia of Rs 1 lakh each to the next of kin of the deceased and Rs 25,000 each to the injured.

2.11.7.4 Recommendations

1. Ensure that all villages are connected with landline and mobile facilities.
2. Effective Alarm systems should be identified in case of disaster. Such systems may be helpful to sleeping populations during a disastrous event. Church bells are most effective as all villages have a church. A separate Ring Code, designed specifically for disasters, may be assigned for church bells.
3. The Log Drums could be revived as backup to support church bells for emergencies in the event of destruction of bell towers.
4. Drainage systems should be properly planned and taken care of.
5. Legal/Community action should be initiated against persons responsible for blocking and/or choking drains.
6. Water is a scarce commodity in most parts of the state. Preventing the disposal of waste into stream channels can help increase the amount of usable water. This should also include the prevention of construction of latrines, pig sty etc. on stream channels and diversion of waste waters and septic tank wastes into the channels.
7. As Highways are important lifelines, the District Administration should ensure that landowners' do not interfere with emergency needs such as widening of roads, side cuttings etc. thereby allowing the agencies concerned to keep the roads open to traffic. The administration should play a proactive role in immediately negotiating and acquiring land using all possible means in affected areas.
8. Acknowledging that a major part of the State is unstable and that many segments of the Highway are extremely weak, it should be ensured that Goods Carriers plying on the various highways do not exceed the recommended weight. For the purpose Weigh Bridges should be set up at the foothills, just before entry into the hilly terrain to check and detain vehicles that are overloaded.
9. Signboards cautioning drivers to be wary of Falling Rocks, Toppling Hillsides etc. should be placed at strategic points such as Paglapahar Area, Dimapur District, Lalmati area, Kohima District and at various sensitive areas along NH-39.
10. Excavation for rocks along highways should be discouraged. Such activities destroy road surfaces besides causing debris slides during the monsoon.

2.11.7.5 Lessons Learnt

1. The stability of a natural slope in unsaturated ground conditions needs to be evaluated, using a combination of the progress of moisture infiltration into unsaturated slope and the conventional slope stability analysis.

2. Always be watchful on hill roads and try to note features like cracks on roads or slopes, blocking of drains and seepage points.
3. Always seal the tension cracks or fissures to prevent percolation of water.
4. Always try to keep the drainage channels free from obstructions.
5. Always maintain a gentle gradient on hill roads for smooth traffic movements and to have less vibrations due to overloaded vehicles.
6. For critical locations, always look for alternate alignments, which should be based on landslide hazard zonation studies.

2.11.7.6 References

1. https://www.aljazeera.com/news/2005/5/27/mudslides-kill-many-in-india
2. http://www.e-pao.net/GP.asp?src=3.11.270505.may05
3. https://nsdma.nagaland.gov.in/sites/default/files/201909/Nagaland%20State%20Disaster%20Management%20Plan.pdf
4. https://egyankosh.ac.in/bitstream/123456789/25180/1/Unit-12.pdf

2.12 MANIPUR

As it is a hilly state, land-slides and mudslides are quite common. In 2004, severe landslides affected Senapati District. Even at present, mudslides due to construction of Jiribam-Tupul Railway line have affected many families in Tamenglong District. Landslides are one of the natural hazards that affect at least 15% of land area of our country exceeding 0.49 million km^2.



Figure-137: Landslide Hazard along NH-39, Manipur (Source: Manipur SDMP 061113 Vol 1)

Landslides of different types occur frequently in geodynamically active domains in Himalaya, North East India and also in stable domains in Western Ghats and Nilgiri Hills of southern India. The Himalaya terrain, being geologically young and geodynamically active to triggering large of number of earthquakes and intensive soil erosion, is highly prone to the landslide hazards.

Due to increase in population density in these terrains, especially over the last few decades, the incidences of landslides have shown a rising trend. This is really disturbing and damaging as the landslide hazard many a times causes loss of precious human lives and destruction to their property. This also leads to degradation of the environment.

ELEMENTS AT RISK: Hill districts of Manipur i.e. Churachandpur, Tamenglong, Senapati, Ukhrul and Chandel are most vulnerable to Landslides.

2.12.1 LANDSLIDE IN 2005

2.12.1.1 Introduction

Manipur experienced heavy rain that began on 28 July, 2015 which leads to worst flood in 200 years and landslide in Chandel District. All main major rivers were overflowed causing havoc and washing away connecting bridges, breaching of embankments, cutting off many villages from the mainland. The situation is getting serious as water level recede but low lying areas are still inundated and many habited areas in Thoubal and Chandel districts are left water logged with muddy water and sand. Meanwhile, a major landslide in Chandel District on 1st August 2015.

2.12.1.2 Impact

1. According to the news reports, at least 20 people have lost their lives.
2. The landslide swept away Joumol village. Moreh town, in Indo-Myanmar border, Jiribam on the Assam border, Kasom Khullen in Ukhrul District, have been cut off from rest of the state due to landslide and destruction of bridges. The Manipur Relief and Rehabilitation department estimated that the district has lost up to 90 percent of the standing crops. According to the crop damaged report, rice cultivated in some 34,960 hectare had failed and they didn't yield anything in that season. Widespread of flooding and landslides in six districts out of the nine districts in Manipur impacted to the communities and road connectivity. Six bridges constructed on the Chakpi River were washed away by the turbulent water in Manipur Chandel District.
3. Landslides and gushing water washed away the standing crops, jhum fields and terrace farms in the hills. In the valley, standing crops were severely damaged and inundation continues in low lying areas.



Figure-138: A collapsed house in Manipur (Source: https://reliefweb.int/sites/reliefweb.int/files/resources/manipur-jna-flood-2015-report-6-pm-24-08-2015-sphere-india.pdf)



Figure-139: People look at the bridge which is washed away by the flood water in Thoubal District in Manipur (Source: https://www.indiatoday.in/india/story/landslide-in-manipur-near-myanmar-border-kills-21-285936-2015-08-01)

4. Villagers from Senam and Tengnoupal vacated their houses to move to safer locations. While landslides also hit houses in Hollenjang, Wayang and Tuitung villages in Chandel, 26 houses at PM Dingpi village were swept away due to heavy rainfall.
5. The Imphal-Ukhrul road caved in by three feet and over a stretch of 50 metres at the Naga gate near Ukhrul district hospital, Hungdung halting movement of all heavy vehicles.
6. The Kamjong-Ukhrul road, Manipur's second approach road to Myanmar that connects 30 villages in the area, remained cut off for three continuous days due to landslides and heavy rainfall.
7. MLA/MDC has distributed food items like rice and medicine in a small quantity.
8. Civil society organization spearhead Kuki Khanglai Lompi, Young Paite Association etc collected donation among the non-affected community for the purpose of supplying food and clothing items. Donation also received from social media groups, Kuki Worship service and individuals across and outside the country.
9. MDC of Sangaikot constituency initiated clearance of mud/sand which is blocking roads to the level of 4/5 feet thick by hiring of earth mover.

2.12.1.3 Actions Taken

1. NDRF immediately moved forces to Manipur.
2. The local administration launched a massive relief and rescue work in the region.

3. The local administration helped in moving people to relief camps set up.
4. The state government set up relief camps in Thoubal and Chandel districts for displaced villagers.

2.12.1.4 Recommendations

1. Psycho social support to women, children as well as men for getting them out of fear situation and to motivate them to live their life normally.
2. Capacity building of community to cope with mental fear and trauma
3. Assessment of security of women and children such as sexual abuse or child abuse/ exploitation.
4. Wide dissemination of model land use practices in hill areas for different developmental activities.
5. Launching awareness campaign on landslide and risk reduction and sensitizing all stakeholders on landslide hazard mitigation.
6. Establishing appropriate mechanisms for compliance reviews of all land use of Govt. premises as per bye-laws in hilly areas.
7. Preparing DM plans with specific reference to the management of landslide disaster.

2.12.1.5 Lessons Learnt

1. As rainfall is unmanageable or to rectify the faulty geological parameters by geo engineering projects are costly, it may seem that there is no possible cure for the problem. But as the saying goes, something is better than nothing, we should now react ourselves to that something mode instead of the present nothing mode. Only we need to act as an organised mechanism against this disaster.
2. An effective mode of awareness to the persons utilizing the slopes by the state government is inevitable going parallel with the scientific hunt to prevent landslides.
3. The ground level persons, viz. the people who are constructing houses on the hill slopes are should be educated about the simple use of safety measures while utilizing the slopes.
4. Brief brochures and publicity on the first hand information of landslide needs to be propagated.
5. Or simply the local or the district administration can devise to develop early warning system during peak rainy seasons (Darjeeling and East Sikkim districts have already devise an early warning system for landslides). Such measures are very cost effective comparing with those huge scientific researches where funding is involved.

2.12.1.6 References

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4. http://e-pao.net/epSubPageExtractor.asp?src=education.Science_and_Technology.Landslide_disaster_Are_Mitigation_measures_effective_By_Herojit_Nongmaithem

2.13 JAMMU & KASHMIR

The Union Territory of Jammu and Kashmir witnessed many natural and man-made disaster i.e. landslide, earthquake, floods, forest fire, droughts and avalanches; since history due to its geological and physical settings causing loss of resources and human lives. Enhanced vulnerabilities of the built environment make the State highly prone to disasters.

Despite the fact that great importance is attributed to landslide data compilation, the process of development and updating of landslide. Data of landslide disaster from 1st January 1982 to 20 August 2018 is given in detail in Multi-hazard Risk Assessment for the UT, Jammu and Kashmir: Data Inventory Report prepared and submitted by RMSI Private Limited, India. According to this report, there were 80 events of landslide in Jammu & Kashmir and proclaimed causalities of around 333 persons.

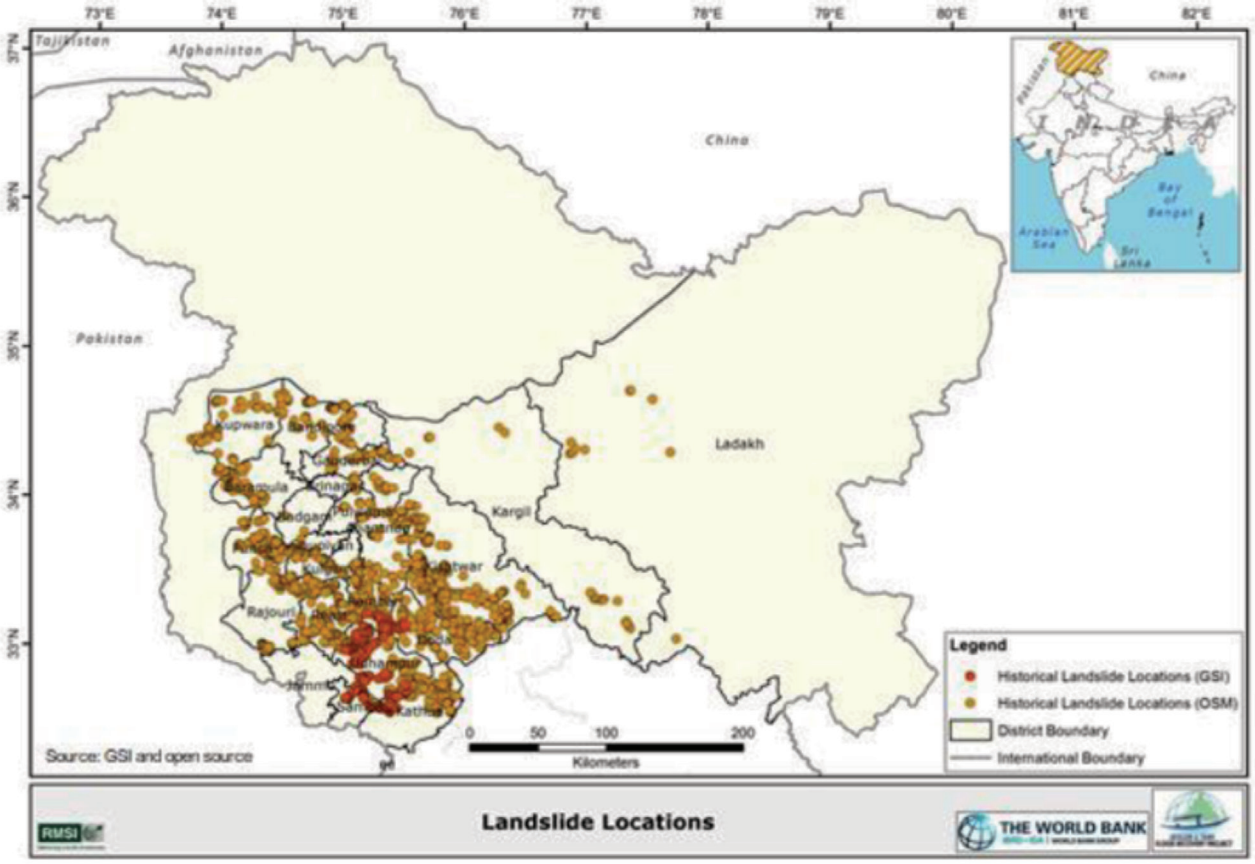


Figure-140: Historical landslide inventory of Jammu and Kashmir
(Source: Multi Hazard Risk Assessment for the State of Jammu & Kashmir 2018)

Below is the table illustrating the historical landslide events occurred:

Table 16 Catalogue of historical landslide events in Jammu & Kashmir (Multi Hazard Risk Assessment for the State of Jammu & Kashmir 2018)

S.No	Date	Affected area	Casualties	Impacts, other than casualty
1	20-Aug-18	Kishtwar	4	Huge boulders and debris came down hitting mini-bus and a car (both vehicles damaged) plying on the Doda- Kishtwar road leading the casualty and injuring one person
2	20-Aug-18	Kulligad, Kishtwar	4	1 person injured
3	21-Jul-18	Banihal		Hundreds of vehicles, including a Jammu-bound convoy carrying Amarnath pilgrims, were stranded. Incident happened during heavy rains
4	15-Jul-18	Doda-Kishtwar Highway	7	12 person injured
5	16-Jun-18	Peddar Tehsil, Kishtwar	3	Five children injured. The landslide hit the shack on the road side causing death and injury of people living in it
6	31-Mar-18	Ladden Chadoora, Budgam	16	Traffic disrupted for over 10 days
7	3-Mar-18	Panthal stretch, Ramban	2	One car was badly damaged by the landslide. The Jammu-Srinagar highway was closed to traffic for almost a day due to landslide
8	13-Aug-17	Panthal-Batote-Doda-Kishtwar		Fresh snowfall around Jawahar tunnel and landslides at Digdole and Panthal resulted in closure of the 294- km Srinagar-Jammu highway. About 30-40 vehicles were stranded at different places on the highway
9	21-Jun-17	Bali Nallah, Udhampur		Over 200 vehicles were stranded at various places on the highway
10	13-Mar-17	Panthal, Ramban		The Jammu-Srinagar highway was closed to traffic for over 3 days
11	20-Feb-17	Ramban		The Jammu-Srinagar highway was closed for traffic due to multiple landslides
12	5-Feb-17	Ramban and Digdol		Over 2,000 vehicles, including trucks loaded with essentials and tankers, were stranded on the highway due to the landslide

S.No	Date	Affected area	Casualties	Impacts, other than casualty
13	17-Mar-16	Batote-Doda National Highways	5	Five injured due to landslides triggered by incessant rain
14	22-Sep-15	Banihal		Jammu-Srinagar highway was closed for traffic for 3-4 days due to landslides triggered by heavy rainfall
15	26-Jul-15	Baltak road, Ladakh Highway		Ladakh highway and the Baltak road for Amarnath pilgrims got washed away at many places leading to massive blockages after landslides triggered by cloudbursts
16	26-Feb-15	Banihal	2	Two seriously injured and a vehicle totally damaged on the Jammu-Srinagar highway
17	19-Jul-11	Doda	3	-
18	9-Jun-11	Kishtwar	3	Eight shops and 10 kiosks destroyed, dozen vehicles damaged
19	18-Apr-11	Phimram Shangus	5	All the 5 killed were of one family and another person was injured by this landslide triggered by heavy rain
20	4-Mar-11	Uri	1	Four houses damaged
22	14-Feb-11	Ramban		About 1,200 vehicles stranded as Jammu-Srinagar highway was closed for traffic after flash floods and heavy rains triggered landslides in Ramban District and damaged the highway
23	12-Feb-11	Doda	2	1 injured
24	23-Oct-10	Uri district	3	Casualty of 3 army personnel. Landslides, triggered due heavy rains, hampered traffic movement
25	3-Oct-10	Kishtwar	3	Casualty of 3 army personnel
26	7-Sep-10	Leh	2	1 injured
27	10-Aug-10	Uri	1	7 injured
28	6-Aug-10	Chang-la pass, Ladakh	145	The flash floods and mudslides triggered by cloudburst at Leh on 5th and 6th August 2010 destroyed more than 50 houses. Several villages along the Chang-la pass and stretches of road washed away. Apart from reported casualties, several people went missing

S.No	Date	Affected area	Casualties	Impacts, other than casualty
29	25-Jul-10	Ramban	-	Landslide triggered by heavy rains near Panthal between Ramban and Ramsu blocked the Jammu Srinagar highway. Amarnath pilgrims were stranded on the highway
30	6-Jun-10	Uri	6	Traffic disrupted for several days
31	4-Jun-10	Leh	-	-
32	27-May-10	Turtuk area of Nubra valley	-	A school bus with 15 children on board was trapped and army personnel evacuated them
33	26-May-10	Ladakh		20 houses damaged
34	25-May-10	Chadiyan village Baramulla		Several houses damaged. Affected Chadiyan village located on a mountainous slope near the border town of Uri in Baramulla district
35	20-May-10	Srinagar	1	-
36	20-May-10	Leh	1	Army personnel was killed, hit by a heavy boulder during the landslide. Location near Siachen base camp Nobra, about 500 km from Srinagar, in Leh district
37	18-May-10	Vaishno Devi	2	-
38	18-May-10	Leh-Karu-Tangtse axis in Ladakh	2	Location two km short of the 17,350 ft Chang La top on Leh-Karu-Tangtse axis in Ladakh region. The Indian Army rescued 73 trapped people
39	18-May-10	Batote - Kishtwar Highway, Doda		Landslide triggered during widening of road stretch at Ragi Nallah, about 150 km from Jammu, on Batote - Kishtwar highway in Doda district led to the closure of the highway
40	17-May-10	Srinagar-Leh National Highway		The traffic on the 434-km Srinagar-Leh national highway was suspended after heavy landslides occurred at Captain Mode, 100 km from Srinagar, and other places on the highway due to incessant rain for the past one week
41	28-Apr-10	Gandarbal, Srinagar	1	Srinagar-Leh highway closed
42	28-Apr-10	Srinagar-Leh National Highway	1	Heavy rains caused landslide along the Srinagar - Leh national highway, killing a BRO laborer

S.No	Date	Affected area	Casualties	Impacts, other than casualty
43	20-Apr-10	Zojilla Village		Incessant rains caused landslides at many places on Srinagar-Ladakh highway and the highway was closed due to landslides at Zojilla
44	27-Feb-10	Siachen Glacier	2	
45	27-Feb-10	Reasi	2	Casualty of two pilgrims. Location of landslide at Hathi Matha, in Reasi district triggered due to heavy rains
46	22-Feb-10	Uri	1	6 injured
47	22-Feb-10	Chairvani Village, Ganderbal	6	6 injured in Chairvani Village, Ganderbal District
48	10-Feb-10	Gulmarg	3	--
49	8-Feb-10	Kishtwar	1	6 injured, 5 houses damaged
50	8-Feb-10	Vaishno Devi	17	--
51	9-Jan-10	Kupwara district	4	--
52	3-Jan-10	Vaishno Devi		1 injured
53	3-Jan-10	Reasi		Landslides triggered due to heavy rains injured one pilgrim.
54	12-Dec-09	Kishtwar	1	--
55	12-Dec-09	Keran Sector, Kupwara	1	The person killed was a BRO porter
56	23-Sep-09	Vaishno Devi	3	--
57	2-Aug-09	Amarnath	2	--
58	2-Aug-09	Atholi, Kishtwar	1	Two injured
59	29-Jul-09	Kupwara	3	Tourism affected killing three pilgrims
60	29-Jul-09	Vaishnodevi cave shrine in Reasi	1	The person killed was a woman pilgrim and two others were injured
61	17-Jun-09	Gurez	1	4,000 pilgrims stranded
62	6-Feb-09	Srinagar	4	--
63	20-Nov-08	Kishtwar district	6	--

S.No	Date	Affected area	Casualties	Impacts, other than casualty
64	26-Oct-08	Leh	2	32 cattle killed
65	2-May-08	Kathua	8	Several missing
66	31-Mar-08	Qazigund	2	1 injured
67	18-Feb-08	Uri	1	--
68	8-Feb-08	Ramban, Banihal	3	15 injured, 400-500 trucks stranded
69	10-Jan-08	Udhampur	15	-
70	9-Jan-08	Srinagar		200 vehicles stranded
71	8-Jan-08	Poonch	1	850 vehicles stranded
72	17-Dec-07	Ganderbal, Srinagar	2	6 injured, temple, bridge and army bunker damaged
73	10-Jul-07	Doda	2	--
74	25-Jun-07	Banihal	3	--
75	18-Mar-07	Khabbak Village	2	5 missing
76	22-Feb-07	Malori, Jammu		Highway closed and more than 100 vehicles stranded
77	16-Feb-07	Ramban	1	3 missing
78	1-Jun-95	Pani nallah, Kishtwar	6	Section of Jammu Srinagar highway badly damaged
79	1-Jan-94	Bali Nala and Narsoo slide		Section of Jammu Srinagar highway badly damaged
80	1-Jan-82	Ramgarh		Road and communication lines disrupted (NH-1)

Kumar and Tyagi 2021 illustrated the occurrence of landslide hazards after September 2018 in Jammu and Kashmir through secondary sources. The Landslide data inventory in this article contains spatial temporal data and its socio-economic impact on the UT (Table 17).

Table 17 Landslide Inventory in Jammu & Kashmir from September 2018 to April 2021 (Kumar and Tyagi 2021)

S.No.	Date of Occurrence	Place of Occurrence	Socio-Economic Impact	
			Casuality	Injured
1	17 April 2021	Pathiyal cafeteria morh and Digdol (Ramban)		

S.No.	Date of Occurrence	Place of Occurrence	Socio-Economic Impact	
			Casuality	Injured
2	23 March 2021	Chanderkole Banihal (Ramban)	-	-
3	03 March 2021	Shabanbas Banihal (Ramban)	-	-
4	27 February 2021	Ramsoo (Ramban)	-	-
5	09 February 2021	Marog (Ramban)	-	-
6	06 January 2021	Panthiyal, Ramsu, Nashri (Ramban-Udhampur)	-	-
7	19 December 2020	Bhoom, Chandekot (Ramban)	-	-
8	12 December 2020	Gurmul (Doda)	-	-
9	23 November 2020	Qazikund (Ramban)	-	-
10	07 September 2020	Gand top Basamtgarh (Udhampur)	-	-
11	29 August 2020	Dalwas Nashri Peedha (Ramban)	-	-
12	25 August 2020	Khour Reasi	04	-
13	20 August 2020	Trishul Morh Battery Chashma (Ramban)	-	-
14	21 May 2020	Panthiyal (Ramban)	-	-
15	17 May 2020	Banihal (Ramban)	02	-
16	18 April 2020	Several Places Battory Chashma (Ramban)	-	-
17	05 April 2020	Marrog (Ramban)	-	-
18	27 March 2020	Dalwas Village (Ramban)	-	-
19	04 March 2020	Peera (Ramban)	-	-
20	22 January 2020	Chanderkote (Ramban)	-	-
21	16 January 2020	Digdol Monkey Morh Moum Passi Pathjal (Ramban)	-	-
22	08 January 2020	Samroli Cafeteria morh (Udhampur)	-	-
23	25 December 2019	Digdol (Ramban)	-	-
24	15 December 2019	Digdol (Ramban) & Nashri (Udhampur)	02	-
25	15 November 2019	Digdol (Ramban)	-	-

S.No.	Date of Occurrence	Place of Occurrence	Socio-Economic Impact	
			Casuality	Injured
27	11 October 2019	First Bridge (Ramban)	-	-
28	02 August 2019	Nashri (Udhampur)	-	-
29	29 July 2019	Ramsu (Ramban)	-	-
30	25 May 2019	Battory Chashma (Ramban)	-	-
31	15 May 2019	Digdole (Ramban)	-	-
32	09 May 2019	Digdole (Ramban)	-	-
33	24 April 2019	Dharab Shala Thathri (Doda)	05	09
34	13 March 2019	Bathri Bhalleessa (Doda)	-	-
35	17 March 2019	Khari Mahoo (Ramban)	02	03
36	11 March 2019	Kharpura (Ramban)	-	-
37	02 March 2019	Thanpal (Reasi)	-	-
38	26 February 2019	Moum-Pass (Ramsu)	-	-
39	23 February 2019	PakalDul (Kishtwar)	02	-
40	12 February 2019	Maroog area (Ramban)	-	-
41	08 February 2019	Maroog area (Ramban)	02	-
42	30 January 2019	Anokhi fall Ramban)	-	-
43	24 January 2021	Jawahar Tunnel area Pantha Magarkote Khoni Nallah Ramban)	-	-
44	20 December 2018	Khanpur, Banihal	-	-
45	15 December 2018	Gangroo (Ramsu)	-	-
46	15 November 2018	Battery Chashma (Banihal- Ramban)	03	-
47	05 November 2018	Rajouri	03	-
48	30 October 2018	Jammu-Srinagar National Highway (Ramban)	01	-
49	20 October 2018	Banihal (Ramban)	-	-
50	09 October 2018	Jammu-Srinagar National Highway (Ramban)	-	-
51	25 September 2018	Gandoh (Doda) and Kathua	5 and 2 Respectively	-

2.13.1 NASHRI LANDSLIDE

2.13.1.1 Introduction

It is an old landslide located at 131.8 km between Batote and Ramban on the 300 km long Jammu - Srinagar National Highway-1A. What started as a small slide in 1956 has developed into a nightmare that affects the road connectivity almost every year now, especially during monsoon period. Nashri landslide on the Jammu-Srinagar National Highway on Nashri bypass is under cut by river Chenab. The Chenab River is one of the trunk streams flowing through the area. There are a number of slides active in this zone. It also adversely affects the 'Amaranth Yatra' quite frequently. The importance of highways both from the economic and strategic angles, cannot be overemphasized. Often this slide is accompanied with sinking of road several meters and consequently the highway is shifted by side cutting the hill rock, thereby further accentuating deteriorating the condition, impact of which lasts for several years.



Figure-141: A distant view of Nashri Landslides, J&K (Source: GSI Report, 1967)

2.13.1.2 Impact

The landslide has been occurring for several years; a detailed description is given below-

Table 18 Details of Past landslides (Nashri Landslide)

Year	Description
1913	The slopes at Nashri are covered with fairly dense forest of Chir, Pine and Oak that have stood safe for centuries.
1914	The lush green stable slope (average inclination 30°) was cut to provide 3.6 m wide Banihal cart road to cater to light traffic.
1914-52	No significant landslide problem occurred during these 38 years.
1953	A forest fire occurred at Nashri robbing the slope of its vegetative cover; it is believed that this sowed the seeds of instability.

Year	Description
1954	A small landslip took place at an elevation of 880 m at the toe of the slope, primarily due to under-cutting.
1956	The landslide had grown & occupied 40 m width of the road, with its crown at about 80 m above.
1956-65	The landslide continued to get reactivated and enlarged during this period, eventually involving the road at an elevation of 1125 m. Its volume increased very much, as compared to its initial stage in 1954-56. Because of large traffic, the road had to widened, for which blasé was carried out.
1965-79	The position of the road shifted 18 m upslope.
1967	The landslide became very active and its condition rapidly deteriorated thereafter.
1972-73	The landslide was repeated in a big way; it involved back cutting of road by about 45 m.
1974	The width of slide increased to 80 m. The debris material extended to 119 m above the road level, as against the 165 m in 1965.
1977-83	The hill face between major and minor Nashri slides was rendered highly unstable and signs of slope distress were clearly discernible.
1979	A patch of 250 m of the slope sank by about 25 m. The subsidence was accompanied by development of cracks and fissures in its neighbourhood and at the flanks, back cutting measured 55 m from the 1956 position.
1981-82	The landslide got reactivated which increased dimensions & became more rigorous.
1982	Minor Nashri slide which developed on the slopes adjacent to the major Nashri slide, almost equalled the major Nashri slide. The impact of the slide was severe and the road got blocked as many as 13 times during the period from 23 June to 5 July 1982 during which 250 m long road sank by 25 m. About 1,000 vehicles and 5,000 passengers to Kashmir Valley got stranded for 3 days in December 1982.
1983	About 250 m long road sank by 65 m.
1984	The Nashri slide measured about 340 m along the slope above road level and 300 m wide at the road. The uphill slopes were found to range between 30° and 60°. These became highly disturbed and showed innumerable crack. The first crack was 10 to 15 m behind the crown and the second crack at 30 m above it. The area showed slumping between 30 to 150 cm. A set of remedial measures were recommended by Central Road Research Institute of India.
1987	There was a lull for about 3-4 years
1988	Initially, it covered about 390 m road and engulfed about one km of it with tendency to coalesce with small landslips in the neighbourhood.
1993	A set of control measures were recommended.
2012	The 300 km long Jammu-Srinagar national highway 1-A was closed for 12 hours for vehicle movement due to landslide caused by heavy rainfall in the mid night. Thousands of vehicles and hundreds of pilgrims were stranded between Batote and Ramban.
2018	7 causalities happened.

This slide has been a major problem for the last 40 years, obstructing vehicle movement during the monsoon and winter rains. The slide covers an area 400 m wide along the road and 1,000 m long along the slope. The landslide started in 1953, after a jungle fire destroyed its protective vegetative cover and exposed rocks to weathering. In the following years, the slide became increasingly active as a result of the combined effect of surface slide, undercutting of debris at the toe by a nullah (stream) and rain, increasing the frequency of landslides in subsequent years with a road blockage lasting 13 days in 1982. The landslide affected area lies in the vicinity of Murree Thrust to the South and the Panjal Thrust to the North (ICIMOD Report, 1996).

The chronology of significant occurrence of Nashri landslides are summarized in Table-12 is reported to have first occurred in 1956 involving a 40 m stretch of a road affecting about 80 m of slope uphill. The Table-12 suggests that the slide had enlarged considerably between 1956 and 1967. During this period, about 4 million cubic meter of debris (20% - 25% boulders and 75% - 80% clay), derived from the Murree Formation were involved in the mass movement. Nashri landslide causes disruptions and blockage of the road several times a year, requiring urgent action by the Border Roads Organization, the Central agency involved in maintenance of the strategic road all year round. Many vehicles and equipment's buried in the huge landslide debris.

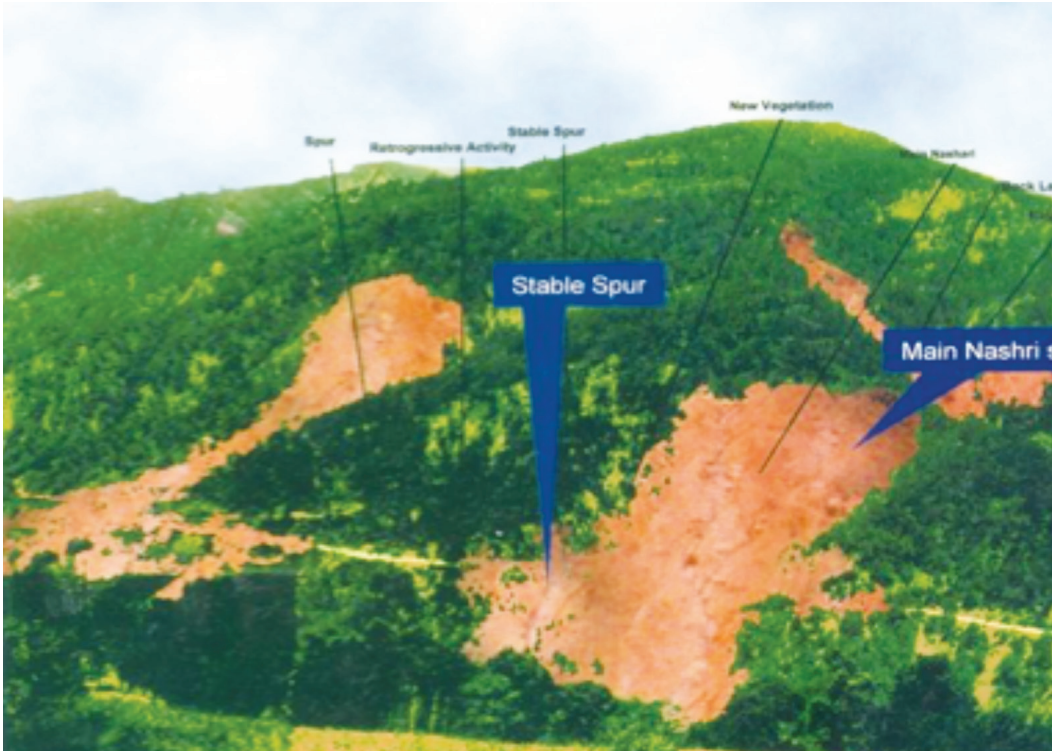


Figure-142: View of the Nashri Landslide in 1983 (ICIMOD, 1996)

The 270 km long arterial National Highway (NH-1A) connects Kashmir valley to the rest of India. In 2010, NH 1A was renumbered as NH 44. The Jawahar Tunnel linking Jammu with the Kashmir across Pir Panjal Range is on this route. Stretches of the highway ran through very precarious terrain. Hence, the blockage of NH has become a recurring phenomenon for past many years. In February 2018, there were reports of devastating landslides triggered after rainfall and snowfall.

More than 2000 vehicles were stranded due to landslides and shooting stones from the hills along highway. Flight prices from Jammu to Srinagar also soared during 5 days long blockage. The closure created problems for local people paralyzing the social life.The digging work of under-construction four-lane highway along existing road at the bottom of steep mountains is the main cause of landslides and shooting stones between Nashri and Banihal. There are dozens of places between Ramban to Banihal and Udhampur to Ramban where digging work is on. Instead of taking up digging work in haphazard manner the contractor companies should have done it in a phased manner. There are more than 15 active landslides and shooting stone spots on the highway from Ramban to Udhampur. The stretch between Ramban and Ramsoo sector is prone to worst landslides and fatal shooting stones.

The enlargement of the slide over the years may be appreciated by examining the extent of slope involved in the failure since 1913 (see Kachroo and Hussain, 1980; Didwal 1988).

2.13.1.3 Actions Taken

Large sums of money have been spent on adhoc half measures mostly doing cosmetic surface treatment of a deep seated movement. The main approach so far has been to clear the debris after landslide down in the valley below (to be washed away by the stream at toe), cut back fresh steep slope, relay the road uphill of the old one and hope for the best. Even today, with so much published literature concerning this landslide, no detailed cross section indicating geologic details, location of slip surface, ground water level and its variations etc., is available. Clearly, we have not done much to understand "how the site works" and the proposed remedial measures so far are more in the nature of a catalogue of all sorts of remedial measures tried anywhere rather than a well-designed program best suited for this site.

2.13.1.4 Recommendations

There is a need of study that in the first place puts together full information about the extent of the landslides that are happening on both sides of the river along the entire affected area. As the area is seismically active also, besides being prone to landslides and floods, including flash floods the measures are to be suggested after taking all the aspects in consideration. Landslides can be triggered by many concomitant causes. Often, individual phenomenon join together to generate instability over time: This often does not allow a reconstruction of the evolution of a particular landslide.

Thus, landslide hazard mitigation measures are generally not classified according to the phenomenon that might cause a landslide. Instead, they are classified by the sort of slope-stabilisation method used:

- Afforestation: Afforestation programmes should be taken up immediately in the hills, as trees has the capacity to attach soil firmly together, reducing chances of landslides in these regions.
- Hydrogeological methods: An attempt to lower groundwater levels or to reduce the water content of the material.
- Proper drainage facilities in these regions is another way to reduce the chances of landslides.
- Chemical and mechanical methods: Attempts are made to increase the shear strength of the unstable mass or to introduce active external forces (anchors, rock or ground nailing) or passive (structural wells, piles or reinforced ground) to counteract destabilising forces.

- Establishment of local monitoring and emergency response systems
- Education and awareness about the impact of landslides: Each of these methods vary somewhat with the type of material that makes up the slope.
- Management of landslides involves coordinated and multi-faceted activities among many stakeholders in the total disaster management cycle, a few of the important recommendations and management plans made are listed below which are based on IS14680:2004 and NDMA Guidelines: Restraining structure, like, retaining walls, anchored walls, restraining piles etc. Easing of pressure by excavation. Reconstruction of slope using reinforced earth Rock reinforcement.

2.13.1.5 Lessons Learnt

1. The NH-1A need to be addressed for reducing the impact of landslides.
2. The steeper slopes along the NH-1A expose weathered, distressed, decomposed, jointed and fractured rocks which move downslope during light to heavy precipitation creating heavy damage both to highway and inhabitants and property along the Highway.
3. An aware and vigilant community sensitized to the warning signs of impending landslides is the vital pillar for implementation of an effective early warning system.
4. Mutual cooperation of planners, engineers and geologists are needed for effective design solutions for long term slope stabilization.

2.13.1.6 References

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2.14 HARYANA

The Sub region of Haryana is vulnerable to a gamut of natural hazards. Geological and geomorphologic setup of Haryana made it prone to a number of natural hazards i.e. floods, water logging, soil salinity, soil erosion, landslides, drought etc. Natural hazards affect the infrastructure and cause loss of natural resources and human lives. Of these, earthquakes, floods, cyclones and landslides rank among the most feared disasters in India and the fear is naturally heightened in the districts Faridabad and Gurgaon in sub region of Haryana and Ambala, Bhiwani, Fandabad, Hissar, Jind and Kurukshetra in rest of Haryana which are affected by multiple hazards.

Morni and Kalka have hilly terrain and deforestation due to urbanisation growth rate is increasing the risk. Landslide would take place in hilly region but it would affect the daily lives of people down the hills, in the plain areas of district in terms of transportation and resources accessibility.

Few recently occurred (in 2022) landslides are discussed in the subsequent section.

2.14.1 BHIWANI LANDSLIDE

2.14.1.1 Introduction

A landslide occurred on 1 January 2022 in Bhiwani District (Haryana State, northern India) at the Dadam mining zone, resulting in casualties.

Preliminary reports suggested that over-exploitation of the mine beyond the permissible limit coupled with climatic conditions led to the cave-in.

2.14.1.2 Impact

According to media reports, the incident took place when landslide struck the mining site at Dadam in Bhiwani district in which five persons had died and two got injured.



Figure-143: Preliminary reports suggest over-exploitation of the mine triggered landslides in bhiwani district (Source: http://timesofindia.indiatimes.com/articleshow/88640161.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst)



Figure-144: The incident took place when landslide struck the mining site at Dadam in Bhiwani district (Source: https://www.hindustantimes.com/cities/chandigarh-news/bhiwani-landslide-one-more-rescued-death-toll-rises-to-five-101641237574173.html)

2.14.1.3 Actions Taken

The Haryana government called in NDRF from Ghaziabad and State Disaster Response Force team from Madhuban and an army unit of Hisar joined the rescue operation.

1. The entire area near the site was cordoned off
2. Rescue team pulled out two excavators and five dumpers from the rubble.
3. Team made huge effort in drilling to break the ceiling of a seven-tonne rock which is 40 feet long and 30 feet wide.
4. The deputy commissioner has constituted a team to investigate the matter and check whether any norms were violated while mining. So far, there is no evidence that illegal mining was carried out at the Dadam mining site

2.14.1.4 Recommendations

It may be necessary to follow technological actions in order to curb the malpractices of the illegal mining sections of the society.

2.14.1.5 Lessons Learnt

1. Mining operations that use blasting techniques often cause other areas that are at the risk of sliding to slide due to vibrations under the soil.
2. Mining evolves through legal and illegal activities and the increase of illegal mining sector is of great concern.
3. Many mines have also not been properly designed or do not operate with designs and most do not apply scientific principles in their operations.

4. Governmental authorities and mining corporations need to establish standards for developing landslides risk assessment and prediction. This should be based on geologist's skills to examine, analyse and monitor areas that are prone to landslide and the potential mechanism of occurrence as well as their frequency of occurrence

2.14.1.6 References

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3. CONCLUSION

Landslide Hazard Zonation Atlas of India was prepared jointly by BMTPC and Centre for Disaster Mitigation and Management of Anna University, chennai. On a pan-India scale, the atlas classified the entire landmass of the country into five zones—severe to very high (Zone-IV), high (Zone-III), moderate to low (Zone-II), and unlikely (Zone-I), on the basis of six parameters: slope, land use, rainfall, geology, geomorphology and tectonics. In 2019, MHA and UNDP jointly conducted a analytical study of Disaster Risks And Resilience In India in which they stated that based on the above classification, 67 per cent of the geographical areas of the country is in landslide-free Zone-I, and 23 per cent in moderate hazard Zone-II, where a landslide is not likely to cause any damage to life and property. It is the 8.5 per cent area in Zone-III and 1.65 per cent area in Zone-IV that are areas of concern. These areas are almost entirely located in 11 Himalayan States and two Western Ghat States, as shown in the Table 19.

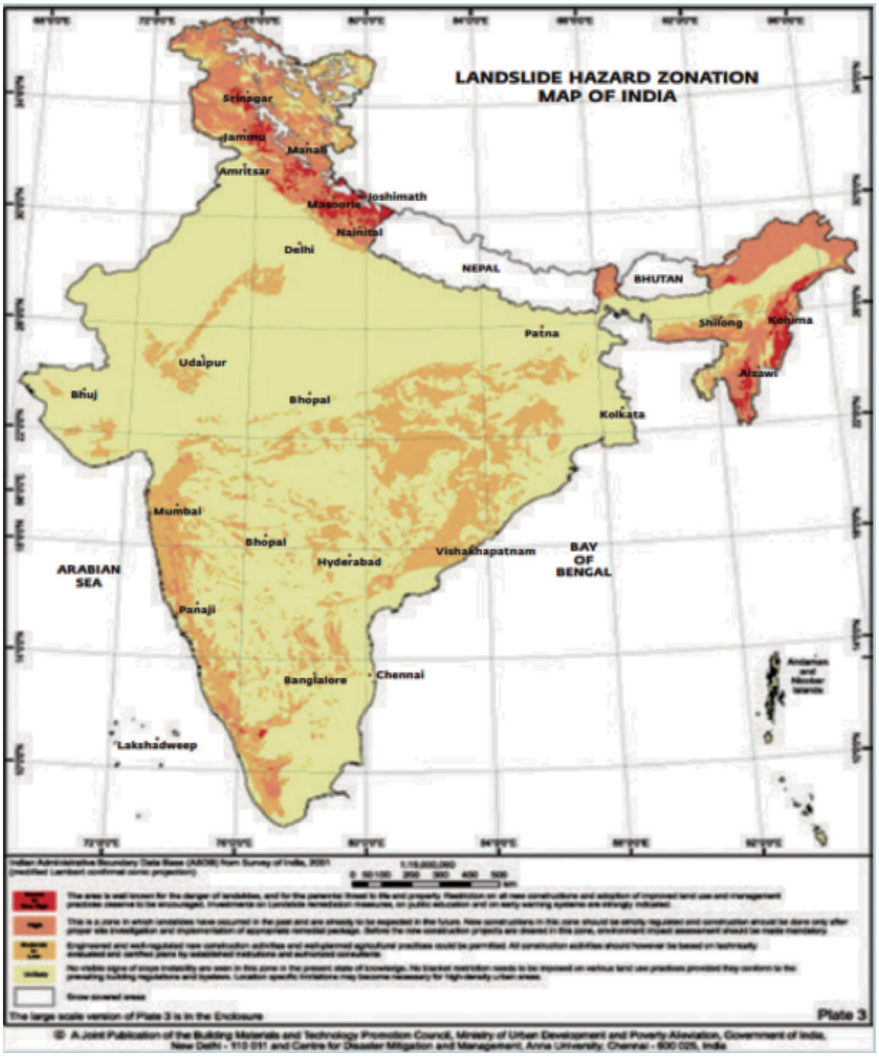


Figure 145 LHZ map of India (Source: https://bmtpc.org/topics.aspx?mid=56&Mid1=186)

Table 19 Major Landslide Hazard Prone States of India (Source: https://ndmindia.mha.gov.in/images/pdf/Disaster%20Risk%20and%20Resiience%20in%20India.pdf)

S No.	STATES	Total Area (Sq. Km)	Moderate (Zone-III)		High (Zone-IV)		Severe (Zone-V)	
			Area	%	Area	%	Area	%
1	Arunachal Pradesh	83743	3590.66	4.29	65159.97	77.81	2505.09	2.99
2	Assam	78438	13475.35	17.18	5947.11	7.58	6.26	0.01
3	Goa	3702	2203.25	59.52	303.5	8.20	0	0
4	Himachal Pradesh	55673	7285.46	13.09	38960.86	69.98	7949.24	14.28
5	Jammu and Kashmir	101387	40161.94	39.61	40129.36	39.58	5604.31	5.53
6	Kerala	38852	22049.62	56.75	9046.27	23.28	355.23	0.91
7	Manipur	22327	2781.4	12.46	11185.7	50.10	6832.69	30.60
8	Meghalaya	22429	9269.2	41.33	9379.62	41.82	256.32	1.14
9	Mizoram	21081	1536.75	7.29	14695.35	69.71	4801.20	22.78
10	Nagaland	16579	3113.67	18.78	9252.87	55.81	3630.56	21.90
11	Sikkim	7096	477.09	6.72	6452.69	90.93	165.62	2.33
12	Tripura	10486	4167.69	39.75	2561.51	24.43	0	0
13	Uttarakhand	53483	7146.38	13.36	23677.37	44.27	19588.30	36.63
	Total	515276	117258.46	22.76	236752.18	45.95	51694.82	10.03
	All India	3166620	730217.95	23.05	267204.56	8.43	52340.02	1.65

Knowledge of past events greatly influences the understanding of where landslide risk and impact will be greatest. Landslides can be caused by either natural processes or anthropogenic activity, but their socioeconomic significance is usually the result of the human-landslide interface. The strong correlation of landslides with other hazards such as earthquakes and cyclones has resulted in an underestimation of the impact of landslides. In addition, small but numerous landslides are not recorded in certain disaster databases many times.

The mountainous region of Himalaya and Western & Eastern Ghats of India are vulnerable to different types of landslides that are triggered either by rainfall, earthquake or caused by anthropogenic activities. Landslides are annual recurring phenomena and cause substantial loss of human lives, livelihoods and seriously impacts the physical, socio-economic and cultural landscape of the country.

The nodal agency for landslide studies in India, GSI has created a database of 61287 number of landslides polygons using both Remote Sensing (RS) and field-based source data, out of which, 28831 landslides have already been field validated.

3656 major landslides occurred across India (2014-2020) were collected by GSI through onsite field investigations under the Post-Disaster Studies programme taken up annually by GSI in all the landslide prone States and UTs as per GSI's Standard Operating Procedure, mainly in response to the requests received from the concerned State Governments. (Fig 146:x-axis represents State/UT and the y-axis the number of documented landslides). For all these landslides, during field validation, GSI collected vital preliminary geoparametric attributes for each of the landslides, including studying its impacts, future vulnerability, and indicating the requirements for future detailed geo-scientific investigations.

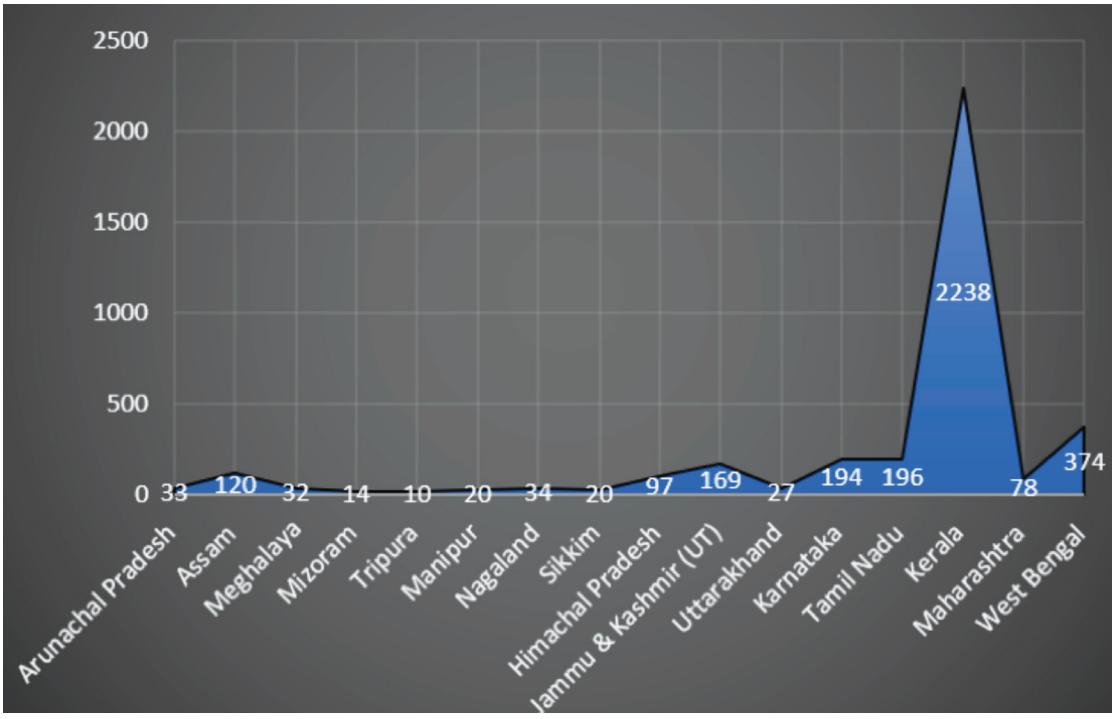


Figure 146 State-wise details of 3656 major landslide incidences (Source: GSI 2014-20)

Although landslides can happen anytime, anywhere but in a broader perspective it can be said that usually from April to December, including the phase of Northeast monsoon, landslide incidences occur in almost all landslide-prone areas. In most cases, these are triggered by extreme rainfall events or cloudbursts. These types of fatal landslide events are common almost every year, mainly in the Himalayan States, in the Western Ghats, and Konkan areas. When the rainfall becomes incessant and much higher than the threshold amount, major landslide events occur, which can cause loss of lives, if elements-at-risk (both static and dynamic) are exposed across its tracks.

As per the author(s) cataloged information of a few significant landslides, one can understand the impact of these events on the social as well as economic sector. Figure 147 gives a graphical representation (x-axis represents State/UT and the y-axis the number of recorded landslides ,1867-2022) of the significant number of recorded landslides in different States/ UT. It's evident that the

majority of the significant landslides have occurred in Jammu and Kashmir, Uttarakhand, Himachal Pradesh, Kerela, West Bengal, Sikkim, Arunachal Pradesh, Maharashtra, Assam, Mizoram, Tamil Nadu, Manipur, Nagaland, Manipur, Meghalaya.

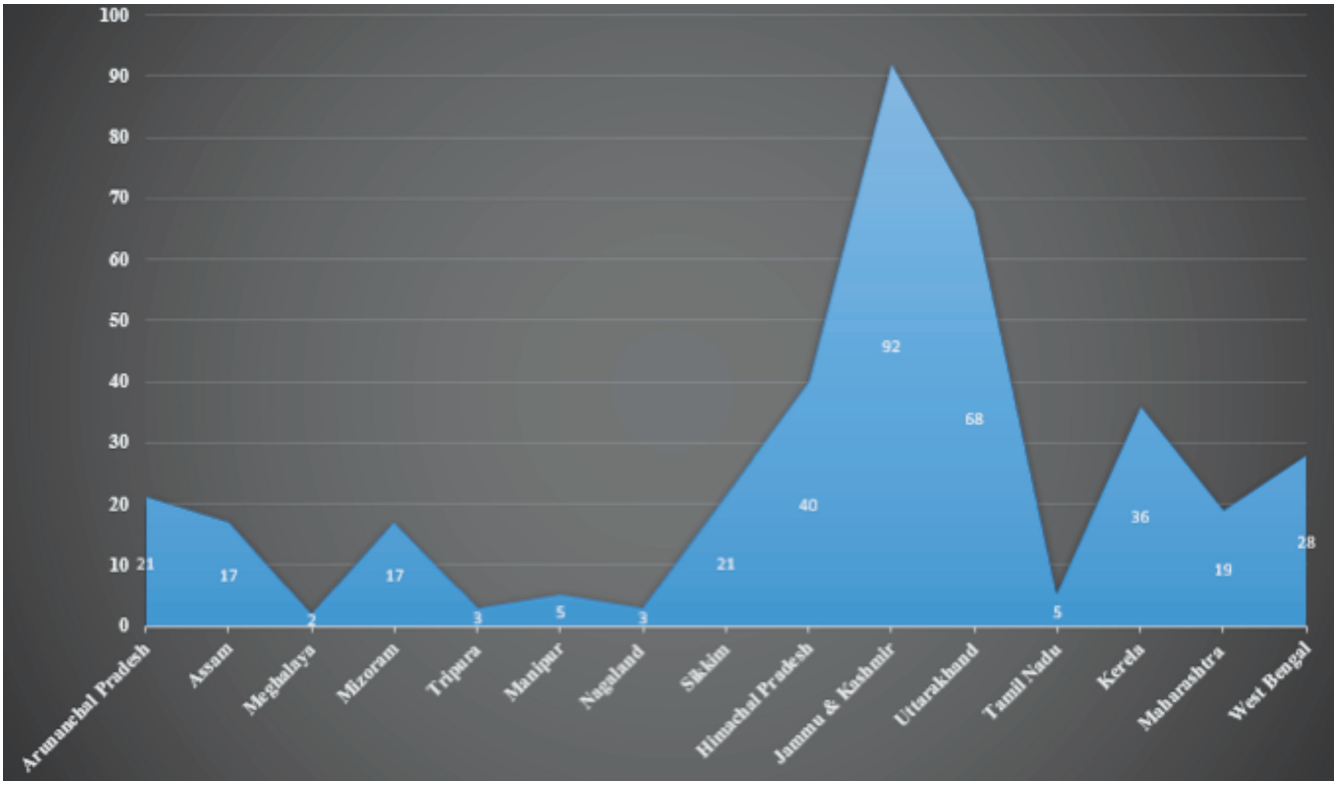


Figure 147 State-wise details of documented significant landslide incidences

The Emergency Events Database (EM-DAT) (Centre for Research on the Epidemiology of Disasters – CRED, 2019) during the period of 1980–2018, recorded 645 fatal landslides resulting in a **total of 34,174 deaths,** based on the statistics from the Centre for Research on the Epidemiology of Disasters (CRED) show that, on average, landslides account for only a small percentage of all deaths from natural hazards worldwide. EM-DAT provides **geographical, temporal, human and economic information** on disasters at the country level. The table 20 highlight the segregated data obtained from EM-DATA, specifically for landslides. The estimated damage is given in US$ (in thousands) in the value of the year of occurrence. Empty fields in the EM-DAT database usually indicate **missing values or non-reported information**.

The published report by **National Crime Records Bureau** (NCRB) on accidental deaths and suicides in 2019 highlights that 264 Indians died in landslides. Over 65% of these fatalities happened in the Himalaya and the Western Ghats.

Table 20 CRED Landslide Database (Source: CRED)

Year	Event	Location	Date	Total Dead	No. of Injured	No. of Homeless	Total Affected	Reconstruction Costs ('000 US$)	Total Damage ('000 US $)
1948	Landslide	Assam	18-09-48	500					
1968	Landslide	Bihar, Bengal	01-10-68	1000					
1978	Landslide	Northeastern	05-11-78	64					
1979	Landslide	Lahaul, Pangi	Mar-79	230		5000		5000	
1979	Landslide	Uttar Pradesh	19-08-79	42	12	100		112	
1980	Landslide	Uttar Pradesh	25-06-80	150					
1983	Landslide	Sikkim	Sep-83	67					
1986	Landslide	Uttar Pradesh, Himachal Pradesh	Jul-86	88			2500000	2500000	
1988	Landslide	Uttar Pradesh, Haryana, Himachal Pradesh, Pendjab states	Jul-88	255					
1989	Landslide	North India	05-08-89	45					
1990	Landslide	Sikkim	16-09-90	30					
1992	Landslide	Aizawl (Mizoram state)	09-08-92	60					
1993	Landslide	Bombay	23-09-93	20	25			25	
1995	Landslide	Mizoram State	03-06-95	40			14285	14285	4500
1995	Landslide	Kulla (Himachal Pradesh)	12-09-95	400			1100000	1100000	
1996	Landslide	Karnataka andhra Pradesh, Maharashtra	30-09-96	48					
1997	Landslide	Gangtok (city) Level 1 = Sikkim	09-06-97	28	30			30	

Year	Event	Location	Date	Total Dead	No. of Injured	No. of Homeless	Total Affected	Reconstruction Costs ('000 US$)	Total Damage ('000 US $)
1997	Landslide	Darjeeling Hills Level 1 = West Bengal	06-08-97	23			2000	2000	
1998	Landslide	Himachal Pradesh	05-03-98	26					
1998	Landslide	Assam	03-06-98	48	150			150	
1998	Landslide	Malpa village (Pithoragrah district, Uttar Pradesh state)	17-08-98	239		200000		200000	
1998	Landslide	Mansuna village (Uttar Pradesh state)	19-08-98	37					
2000	Landslide	Moradabad, Bijnor districts (Uttar Pradesh province), Uttarakhand province	June.2000	43					
2000	Landslide	Ghatkopar village (Mumbai Suburban district, Maharashtra province)	12.07.2000	58	38	7000		7038	
2000	Landslide	Pithoragarh, Naini Tal districts (Uttarakhand province)	11.08.2000	86					
2001	Landslide	Rudra Prayag district (Uttarakhand province)	16-07-01	27					
2001	Landslide	Chamba district (Himachal Pradesh province)	14-08-01	16					

Year	Event	Location	Date	Total Dead	No. of Injured	No. of Homeless	Total Affected	Reconstruction Costs ('000 US$)	Total Damage ('000 US $)
2001	Landslide	Amboori village (Thiruvananthapuram district, Kerala province)	09-11-01	55					
2005	Landslide	Guwahati city (Kamrup district, Assam province)	24-08-05	12	20			20	
2008	Landslide	Administrative unit not available districts (Jammu and Kashmir province)	08-02-05	37					
2009	Landslide	Pithoragarh district (Uttarakhand province)	08-08-09	45					
2009	Landslide	Lal, Bahadur, Shastri, Nagar slums (Mumbai Suburban district, Maharashtra province)	03-09-09	10					
2014	Landslide	Malin village (Pune district, Maharashtra province)	30-07-14	151			200	200	
2015	Landslide	Barpeta, Sonitpur, Goalpara, Dhemaji, Lakhimpur, Tinsukia, Darrang, Nalbari, Jorhat, Kamrup, Dibrugarh, Nagaon,	02-06-15	3		9000		9000	

Year	Event	Location	Date	Total Dead	No. of Injured	No. of Homeless	Total Affected	Reconstruction Costs ('000 US$)	Total Damage ('000 US $)
		Bongaigaon districts (Assamprovince)							
2016	Landslide	Uttarakhand province	22-05-16	10	5			5	
2017	Landslide	Laptap Village, Papumpare district (Arunachal Pradesh)	11-07-17	22					
2017	Landslide	Kotropi, Mandi district (Himachal Pradesh)	13-08-17	46			100	100	
2020	Landslide	Barak Valley Region (southern Assam State, north-east India); Hailakandi; Cachar; Karimganj Districts	27-05-20	21		155850		155850	
2020	Landslide	Idukki district (Kerala state)	07-08-20	70					
2021	Landslide	Bombay	17-07-21	33					
2021	Landslide	Nigul Sari Village (Kinnaur District, Himachal Pradesh State)	11-08-21	35	13			13	

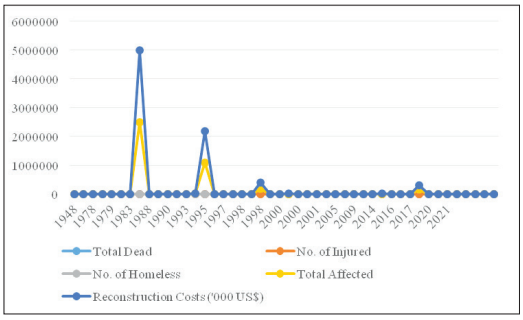


Figure-148: Damaging landslides in India (https://public.emdat.be/data)

Costs are largely direct (Source: loss of lives, infrastructure and measurable resources), but may include some indirect costs.

The purpose of discussing the datasets listed above of GSI, CRED and NCRB is to assist in humanitarian action to rationalize decision making for disaster preparedness; and to provide an objective basis for vulnerability (unsafe buildings, physical infrastructure, social infrastructure, agriculture, livestock, industries, vulnerable women, children, disabled, elderly, poor, water stress, and depleting forests) assessment and prioritization. Measuring risks and resilience at the sub-national level in a large, diverse, multi-hazard country like India is a challenging task. For eg: As a result of the 2013 natural calamity, the activities of the primary sector in Chamoli district were almost wiped out, even after 9 years the primary sector is still facing the after-effects of the disaster and is struggling to recover from the damages. And in this effect again on 7th February 2021 an extreme event devastated the people of Chamoli. Many times a similar situation occurs in sensitive places i.e. till people think of recovering from the memories of the old disaster and its effects and in the meantime another disaster strikes. Globally the approach towards post-disaster restoration and rehabilitation has shifted to one of building back better. Build back better is not limited to the built environment and has wide applicability encompassing the economy, societal systems, institutions, and environment. The Sendai Framework envisages that the stakeholders will be prepared for building back better after a disaster. Existing mechanisms may require strengthening to provide effective support and achieve better implementation. Disaster recovery tends to be very difficult and long-drawn-out. The reconstruction will vary depending on the actual disaster, location, pre-disaster conditions, and the potential threats that emerge at that point in time. Building Back Better (BBB) is an approach to post-disaster recovery that reduces vulnerability to future disasters and builds community resilience to address physical, social, environmental, and economic vulnerabilities and shocks.

The MHA and UNDP 2019, study developed an inter-state difference in population and economy to highlight the difference of State GDP (Table 21). State GDPs present a wide range of difference from Rs 20,01,223 crores (Maharashtra) to Rs 15,339 crores (Mizoram); from Rs 1039924 crores (West Bengal) to Rs 176171 crores (Uttarakhand). The same differences persist in per capita income from Rs 36,648 (Bihar) to Rs 372,117 (Goa). This poses serious methodological challenges, as States with lower level of hazard but higher level of GDP/ per capita would show a high estimation of risks, unless these are normalized with appropriate and uniform criteria.

Density of population also presents a wide range of difference from 17 in Arunachal Pradesh to 1106 in Bihar. Some of the districts of India have population density as high as 25,000 (Kolkata).

Table 22-24 highlights the top 10 countries in terms of frequency of disasters, deaths and mortality rates, direct economic losses and loss rates. In terms of the frequency of disasters, the United States had the highest number at 19, followed by China at 16. **Table 21 Inter-State difference in population and economy (Disaster Risks And Resilience In India-an analytical study)**

Sl. No.	STATES/ UNION TERRITORIES	Area	Population		Per capita (Rs.)	
		(Sq. Km)	Total	Density	Total (Rs. Cr)	Per capita (Rs)
	STATES					
1	Andhra Pradesh	160205	49386799	308	609934	123501
2	Arunachal Pradesh	83743	1383727	17	20294	146662
3	Assam	78438	31205576	398	226276	72511
4	Bihar	94163	104099452	1106	381501	36648
5	Chhattisgarh	135192	25545198	189	260776	102084
6	Goa	3702	1458545	394	54275	372117
7	Gujarat	196244	60439692	308	1033791	171045
8	Haryana	44212	25351462	573	485184	191383
9	Himachal Pradesh	55673	6864602	123	112852	164397
10	Jammu and Kashmir	101387	12541302	124	119093	94961
11	Jharkhand	79716	32988134	414	231294	70114
12	Karnataka	191791	61095297	319	1016910	166447
13	Kerala	38852	33406061	860	556616	166621
14	Madhya Pradesh	308252	72626809	236	508937	70076
15	Maharashtra	307713	112374333	365	2001223	178085
16	Manipur	22327	2855794	128	19233	67347
17	Meghalaya	22429	2966889	132	25767	86849
18	Mizoram	21081	1097206	52	15339	139801
19	Nagaland	16579	1978502	119	19816	100157
20	Odisha	155707	41974218	270	341887	81452
21	Punjab	50362	27743338	551	391543	141130

22	Rajasthan	342239	68548437	200	672707	98136
23	Sikkim	7096	610577	86	16954	277672
24	Tamil Nadu	130060	72147030	555	1161963	161055
25	Telangana	114840	35193978	306	567588	161274
26	Tripura	10486	3673917	350	34184	93045
27	Uttar Pradesh	240928	199812341	829	1120836	56094
28	Uttarakhand	53483	10086292	189	176171	174664
29	West Bengal	88752	91276115	1028	1039924	113932
	UNION TERRITORIES					
1	Andaman and Nicobar	8249	380581	46	5932	155867
2	Chandigarh	114	1055450	9258	29049	275226
3	Dadra and Nagar Haveli	491	343709	700	2440	70990
4	Daman and Diu	111	243247	2191	1059	43536
5	Delhi	1483	16787941	11320	551963	328785
6	Lakshadweep	30	64473	2149	407	63127
7	Puducherry	490	1247953	2547	24701	197932
	Total	**3166620**	**1210854977**	**382**	**13838419**	**114286**

Table 22 Top 10 countries (or regions) in terms of frequency and losses due to natural disasters globally, 2019 (Source:GAR 2019)

Country	Frequency	Country	Number of deaths	Country	Direct economic losses (US$ billion)
United States	19	India	2,307	United States	44.78
China	16	France	1,448	Japan	26.21
Philippines	15	Belgium	716	China	18.33
Indonesia	13	Mozambique	704	India	11.81

India	11	Zimbabwe	654	Bahamas	7.00
Pakistan	11	China	577	Iran	2.67
Japan	10	Indonesia	444	Spain	2.50
France	9	The Netherlands	400	Mozambique	2.23
Brazil	8	Behamas	370	Australia	2.00
Afghanistan, Uganda, Vietnam	7	Pakistan	362	Indonesia	1.30

Table 23 Top 10 countries (or regions) in the global natural disaster losses rate, 2019 (Source:GAR 2019)

Country	Share of deaths (per million)	Country	Percentage of direct economic losses (%)
Bahamas	959.44	Bahamas	56.34
Belgium	62.69	Mozambique	15.15
Zimbabwe	45.29	Nepal	0.70
Mozambique	23.87	Japan	0.53
The Netherlands	23.21	India	0.43
France	21.62	Aibania	0.30
Albania	17.79	United States	0.22
Comoros	9.61	Madagascar	0.18
Djibouti	9.39	Spain	0.18
Bolivia	7.31	Australia	0.14

Table 24 Top 10 natural disasters in global direct economic losses in 2019 (Source:GAR 2019)

Rank	Time	Country	Disaster type	Direct economic losses (US$ billion)
1	October 10th - 17th	United States	Wildlife	250.00
2	October 12th - 17th	Japan	Storms	170.00
3	July 14th - 30th	India	Floods	100.00

4	August 10th - 12th	China	Typhoon Lekima	100.00
5	March 12th - 28th	United States	Floods	100.00
6	October 08th - 08th	Japan	Storms	91.00
7	September 01st - 04th	Bahamas	Storms	70.00
8	June 13th - 01st	China	Floods	62.00
9	September 18th - 24th	United States	Storms	35.00
10	October 20th - 21st	United States	Storms	26.00

Direct costs are often imprecisely recorded. With the passage of every year the costs of landslides may be high, but most interesting are the opportunity costs. When population growth pushes development into less stable regions the land sterilization occurs. Judicious planners are forced to take a sober look at the areas that are prone to landslides and plan accordingly. The opportunity costs continue to rise as a direct result of unstable land being identified and the relative value of stable land as it becomes scarcer.

This document discusses 47 notable landslides recorded since 1867 which are estimated to have resulted in direct and indirect costs killed many individuals and destroyed or buried homes, roads and highways, bridges, rivers, pipelines and other infrastructure vital to the well-being of all Indians. Damaging landslides occur where the natural landscape intersects a socio-economic landscape and most historical landslides of significance have occurred at the human-landslide interface. However, as Indians continue to expand settlement into less stable areas, we need to be ever more cognizant of the landscape in which we live and carefully manage our exposure to unnecessary risks that threaten our livelihood, lives and the infrastructure upon which we rely.

The significant socio-economic effects of landslides in India will continue, as they do elsewhere in the world. In India, landslides disrupt lives, injure people, livelihoods, roads, natural resources, power, energy and communication infrastructure. The collection of socio-economic data not only helps to update and enhance decision-making on policy issues, but also to assess the effective development and impact of social and economic policies.

It is also true that the number of landslides that have occurred will be more than the number of landslides documented by the GSI so far, however, we have documented only 412 landslides. This is because of the lack of both data management and data archiving approaches in the post-disaster documentation of landslides.

Lack of adequate knowledge, skills and information about landslide disasters have aggravated the losses and prolonged the recovery process. Informed, skilled and trained human resources can play a significant role in landslides risk management and loss reduction. NIDM has also developed various training modules like:

1. Comprehensive Landslides Risk Management
   (https://nidm.gov.in/PDF/pubs/LandslidesModule_2020.pdf) and

2. Landslide Preparedness Guidelines for Safety of Buildings on Slopes
   (https://nidm.gov.in/PDF/pubs/Landslide_Preparedness_Guide_.pdf)

The above mentioned modules have been developed with an aim to fill the gap in a proactive mode by imparting skills, knowledge and information related to landslides management. These documents will make people aware of landslide and its causes with main focus on avoidance, prevention and mitigation measures, that common people can understand and implement to protect themselves from landslides, especially those who are living on unstable slopes or their surroundings. The document would help to counter the ignorance and human mistakes that give rise to landslide problems. It is an awareness guide with emphasis on better understanding of landslide hazards with their avoidance, prevention and mitigation for planning, development, maintenance and sustenance of slopes, structures, infrastructures and services with reduced risks and enhanced the resilience of people against disasters.

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3. https://nidm.gov.in/PDF/pubs/Landslide_Preparedness_Guide_.pdf
4. https://www.business-standard.com/article/current-affairs/12-indian-land-prone-to-landslides-as-climate-crisis-increases-the-risks-120100200239_1.html
5. https://ncrb.gov.in/en/accidental-deaths-suicides-in-india?field_adsi_year_value%5Bvalue%5D%5Byear%5D=2019&field_accidental_deaths_suicides_value=5&items_per_page=10

ANNEXURE - A

As per Table 3 the landslides are classified in low, moderate, and high category.

It's easy to define the class on the basis of casualties, injured, affected population but for classifying on the basis of economic damage, few points were kept in mind such as-

- As tentative cost of constructing a suspension bridge as per today's rate is approx 50 crores for 135 m span. Material cost normally around 60% for many civil works but in different type of suspension bridges, construction installation always comes with high price so material cost can be around 50% or 55%.
- For Kalisaur landslide-The direct loss on restoration work, lives loss, and vehicles damage estimated as 299223 USD. The total cost of reactivated Kaliasaur landslide including direct and indirect costs of different particulars works out to be 4 million USD approximately (Source: Negi et al 2013)
- "Udhampur - Ramban section of NH-1A from km. 67.00 to km. 89.00 and km. 130.00 to km 4 lane highway. As per 4th volume of MORTH guideline in 1997, Flood damage for breaches & washing away of bridges cost was about Rs 61000 for less than 450 CVD and Rs 67000 for more than 450 CVD"
- Maintenance costs are currently estimated at Rs 50,000 per km for conventional bitumen-based road.
- Officials of the National Highways Authority of India (NHAI) estimate the average cost of building four lane highways at Rs 8-9 crore per km.
- "Prior to the 1968 landslide, the steep lower part of the valley side was covered with forest (jungle) changing into shrubby jungle with bamboo (degraded jungle) upslope. The gentle slope above was occupied by tea plantations towards the north and two villages Taar Gaon and Darah Gaon closer to the landslide area in the south. The two villages had 174 and 126 homes, respectively landslide was very active following heavy rains in 1983, 1987, and 1988, causing damage to the only road connecting Ambootia with Kurseong. July 17t of 1988 saw a heavy downpour of about 200 mm of rain that continued to fall between 1:30 PM and 5.00 PM. The reactivation of the landslide prompted the damages of another 15–20 homes"
- Four lanes of Solan-Shimla section of NH-22 in the state of Himachal Pradesh.Officials of the National Highways Authority of India (NHAI) estimate the average cost of building fourlane highways at Rs 8-9 crore per km. As 1.5 km NH22 vanished, i.e., on an average 12 cr.
- During winters, snowfall forces it to shut down; in the summers, landslides caused by the rains can force closure. In fact, the 36 km stretch between Ramban and Banihal falls in seismic zone IV and it is closed for 45-55 days in a year on an average. Worse yet, according to GM Bhat, a geologist who teaches at the University of Jammu, the road has 29 major and 19 minor landslide-prone areas
- "Administrative records (PWD Karcham,1996):

  Initial approval for a Karcham–Shaung–Sangla road, including a 'jeepable' link road to Sapni, was given on 26th September 1978. The estimated cost for the road was given as 28,64,000 rupees. Work was started under Kalpa division of Himachal Pradesh Public Works Department (HPPWD) in

1978, and transferred to Karcham division after its creation on 1 November 1980. The road from Karcham to Shaung was completed in the financial year 1984/5 at a cost of about 50,00,000 rupees On 30th June 1988, 7,60,000 rupees were granted to Karcham PWD via the District Commissioner (DC), Kinnaur, to carry out maintenance work on the road. By 10th November 1989, 4,28,000 rupees had already been spent when a section of road lost due to landslide.The estimated cost given by Karcham PWD for restoration of the Karcham–Sapni road is given as 21,83,000 rupees, and the 1989 event is attributed to rain damage (in other words natural disaster)"

- Average Construction Cost using Builder (Material + Labour Outsourced) (https://property.today pricerates.com/)

AREA OF CONSTRUCTION	970 Sq. ft.
CONSTRUCTION ESTIMATE	₹ 1334000 Rs.
CONSTRUCTION COST IN LACS	₹ 13.34 Lacs
COST / SQ.FT	₹ 1450

Apart from these many other relevant parameters need to be considered for classing the landslides in terms of socio-economic impact.

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
1	Landslide at Chamoli garhwal blocked Alaknanda river	1868	Swept 2 villages and killed 70 pilgrims	https://usdma.uk.gov.in/PDFFiles/Traditional[1].pdf	H
2	Nainital Landslide	1880	Massive destruction 151 died	https://usdma.uk.gov.in/PDFFiles/Traditional[1].pdf	H
3	Mundakay	01-07-1984	14 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	H
4	Landslide dam bursted at Gohna	1894	The first account is that "On 6 September 1893, a tributary of the Alaknanda River called Birahi Ganga was blocked by ~5 billion tonnes of the rock mass that rolled from a 900 m high valley flank. The debris blocked the river forming a lake 150 m deep, 3 km long and 600m wide which was constructed much above the anticipated flood level. Similarly, eight suspension bridges between Chamoli and Haridwar were dismantled in order to protect them from being washed away by the anticipated flood. As predicted, on 25 August 1894, water began to trickle over the dam and at midnight the	https://en.wikipedia.org/wiki/Gohna_Lake_dam-burst# cite_note-1	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
			dam was partially collapsed, sending flood surges downstream. The flood lasted until the morning of 26 August causing unprecedented damage to the property around Srinagar, Uttarakhand town; however, no loss of life was reported."		
5	Kumpanpara (Moolamattom)	26-06-1985	9 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	M
6	In and around Darjeeling town	24-06-1899	Due to unprecedented rainfall of 1065.50mm, killing 72 persons and causing enormous loss to land and property	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
7	Guwahati landslide, Assam	18-09-1948	Over 500 people died in the landslide and according to the reports, the landslide buried an entire village	https://www.researchgate.net/publication/322508425_Landslide_Inventory_of_India_1948_-_2017	H
8	Darjeeling, Kurseong and Kalimpong towns	Between the 11th and 13th June, 1950	127 people were killed and several hundreds were rendered homeless. The Siliguri-Kalimpong railway line was closed forever, as the hillsides in that region were considered unsafe for railways	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
9	Kaliasaur landslide	1920, since then Further occurrences of moderate to heavy landslides in 1952, 1963, 1964 and 1965. A major landslide occurred on 19th Sep., 1969. During 1970, 1971 and 1972 repeat of moderate to heavy landslides occurred. Then in September 1984, 1985, August 1986, 2010, 2012	19th September, 1969 blocking nearly three fourth of the river about 100 m below the road level. A 300 m stretch of the road was badly damaged and got dislocated both vertically and laterally by about 2.5 - 3.0 m. During 1970, 1971 and 1972 repeat of moderate to heavy land-slides occurred disrupting the communication system and each time, a new formation width had to be cut. During September, 1984, following heavy rainfall, a major landslide occurred and damaged the road considerably, extending the rear scar of the slide retrogres- sively. The most recent slide was in August, 1986.	https://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=1438&context=icchge	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
10	Nashri slide, J&K	1913 to 1993	Located on the National Highway 1, from Jammu to Srinagar at km 138. Blockage and disruption of national highway, primary connection to Srinagar.	https://www.preventionweb.net/files/2701_icimod9e12bbf9f66156dd 8a85e1f9f3165684.pdf https://morth.nic.isites/ default/files/4-volume-4january1995-december -1997.pdf	H
11	Chakki Dalhousie slide, HP	1965	70 m road subsided at 67-68 km on Pathankot-Dalhousie road	https://www.academia.edu/11180146/Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
12	Darjeeling, West Bengal	4-10-1968	Thousand people died, 60KM long highwaycut in 91 parts	https://www.researchgate.net/publication/322508425_Landslide_Inventory_of_India_1948_-_2017	H
13	Maling landslide in Kinnaur	September, 1968	damaged 1km NH-22 and is still active	https://nidm.gov.in/PDF/pubs/KOTRUPILANDSLIDE_2017.pdf	H
14	Rimbik, Lodhama, Bijanbari, Darjiling town, Sukhiapokri, Manebanjan, Sonada, Tindharia, Happy Valley and Ambootia (Kurseong)	3 and 4 September 1980	due to heavy rainfall of 299.1mm, the mentioned locations in column 1 were affected by severe landslides, killing 215 people and destroying properties worth about 100 million rupees.	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
15	North District, Sikkim	11-09-1983	65 dead GREF Camp wiped out	http://www.sikkimlrdm.gov.in/downloads/publications/sdmp.pdf	H
16	Ambootia Landslide, Kurseong subdivision, Darjeeling District, W.B.	October 2-5 1968, 1983, 1987, July 17th 1988, 29Jun 2008 2009, 2011	October 2-5 1968-Damge to tea estate and many houses. 29Jun2008 -A major landslide took place in Mamring, a village of 170 houses in Kurseong subdivision. Luckily there were no casualties, but because of the impending hazard, 59 families from Mamring were evacuated to a school situated away from the landslides	http://savethehills.blogspot.com/2008/06/preliminary-report-on-mamring-kurseong.html	H
17	Darjeeling-Sikkim Himalaya	3 and 5 October, 1968	In 1968 667 fatalities, several tea gardens were destructed.Numerous bridges were demolished and washed away (e.g. Tar Khola, old Anderson Bridge and Tista Bazar Bridge etc.) The Hill Cart Road and NH 31 were destroyed.	http://iguonline.in/journal/igu%2020-2%20(web)/Paper-6.pdf;http://savethehills.blogspot.com/2019/08/a-document-from-past-my-restored-photo.html	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
18	Belakuchi slide, km 259, UK	July, 1970	The entire village of Belakuchi was washed away by the swirling torrent of Alaknanda alongside several bus loads of tourists.The flood affected an area of about 400km and washed away 5 major bridges, 13 suspension bridges and several million rupees worth of timber and fuel were destroyed.	https://books.google.co.in/books?id=gGq9y-2lidC4C&pg=PA387&lpg=PA387&dq=The+entire+village+of+Belakuchi+was+washed+away+by+the+swiring+torrent+of+Alaknanda+alongside+several+bus+loads+of+tourists.The+flood+affected+an+area+of+about+400km+and+washed+away+5+major+bridges,+13+suspension+bridges+and+several+million+rupees+worth+of+timber+and+fuel+were+destroyed.&source=bl&ots=imgnEfA2NN&sig=ACfU3U-3jtb558VIwHzCi7-JfwduLjf03kw&hl=en&sa=X&ved=2ahUKEwiw6piA7bv6AhXGeN4KHUQ_CasQ6AF6BAgVEAM#v=onepage&q=The%20entire%20village%20of%20Belakuchi%20was%20washed%20away%20by%20the%20swiring%20torrent%20of%20Alaknanda%20alongside%20several%20bus%20loads%20of%20tourists.The%20flood%20affected%20an%20area%20of%20about%20400km%20and%20washed%20away%205%20major%20bridges%2C%2013%20suspension%20bridges%20and%20several%20million%20rupees%20worth%20of%20timber%20and%20fuel%20were%20destroyed.&f=false	H
19	Chamoli district	20-07-1970	Landslide formed an artificial lake in the upper catchment of Alaknanda river; affected 101 villages, >100 persons killed and 142 animals died; about 36 vehicles drowned by flash floods; district headquarter of Chamoli devastated and subsequently shifted to Gopeshwar	http://cidbimena.desastres.hn/docum/crid/Jun-Jul2004/pdf/eng/doc15221/doc15221-contenido.pdf	H
20	Kinnaur	19-01-1975	In Satluj basin two blockages were observed in Spiti valley. One on Parechu River between Sumdo and Kaurik due to landslide created by 19 Jan. 1975 earthquake, which occurred along the Sumdo-Kaurik fault. Blockage was 60m in height and 150m in length created temporary lake. In march this lake burst causing flash floods in Spiti valley	http://ddmakinnaur.hp.gov.in/page/History.aspx	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
21	Sumdo and Kaurik	Jan-1975	In Satluj basin two blockages were observed in Spiti valley. One on Parechu River between Sumdo and Kaurik due to landslide created by 19 Jan. 1975 earthquake, which occurred along the Sumdo-Kaurik fault. Blockage was 60m in height and 150m in length created temporary lake. In march this lake burst causing flash floods in Spiti valley	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	M
22	Naina Devi slide, Bilaspur	1, 6, 18 & 25 Aug 1978	143 houses belonging to 46 families, portion of the road and some steps of temple were carried away	https://lib.icimod.org/record/23535/files/c_attachment_240_1914.pdf	M
23	Ukhimath Landslide	1979	39 persons killed	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	H
24	Ramgarh	01-01-1982	Road and communication lines disrupted (NH-1)	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data inventory-Report_30Nov2018-RMSI.pdf	L
25	Himachal Pradesh	Dec-1982	At solding Nallah, 3 bridges collapsed and about 1.5km of NH-22 vanished	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
26	Rit chu Bridge slide, North Sikkim, km82.3	1982	Bridge washed away 8 times during 1966, 1968, 1970, 1972, 1980, 1981, 1982, 20.06.2016 traffic blocked for months	https://www.telegraphindia.com/west-bengal/bridge-on-north-sikkim-highway-crashes-again/cid/1524989	H
27	Lanta Khola, North Sikkim, km73	1975, 10 and 11 September 1983, 2001	The slide has been active since 1975. In 1975, the area initially developed into a sinking zone following further heavy showers the road bench along with the culvert was washed away. In 1983, a 200 m long stretch of the road bench was washed away by the highvelocity surface runoff caused by persistent heavy precipitation on the 10th and 11thSeptember. The road remained closed for over 6 months, as a 10 m deep, 150 m wide scar was formed at Lanta Khola that extended downto the banks of the Tista River.Again, in 2001, following monsoonal rain, the NSH was blocked in phases for 54 days due to sliding at Lanta Khola.Apart from these periods of catastrophic failure, debris movement on the Lanta Khola occurs periodically almost every year, generally in the aftermath of the monsoons	https://www.researchgate.net/publication/225370707_Rainfall_thresholds_for_the_initiation_of_landslide_at_Lanta_Khola_in_north_Sikkim_India	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
28	Kapkot, Bageshwar	Aug-1984	9 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
29	Landslides at Jakholi in Tehri Garhwal and Devaldhar in Chamoli	1986	32 lives lost	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
30	South Hlimen, Mizoram	11-7-1986	4 persons died	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	L
31	Khuni Nala slide, J&K	1987, 2012, 15-12-2019, 25-10-2021	in 1987 portion of road was damaged; in 2012 seven people were killed;in 2019 3 died ;in 2021 1 died, three people have been critically injured, while the other three suffered minor injuries	https://www.indiatoday.in/india/story/top-crpf-officer-driver-killed-in-kashmir-after-landslide-1628505-2019-12-15 ;https://www.indiatoday.in/india/story/top-crpf-officer-driver-killed-in-kashmir-after-landslide-1628505-2019-12-15; https://economictimes.indiatimes.com/news/economy/infrastructure/will-nhai-be-able-to-complete-the-upgradation-work-of-national-highway-1a-by-2016/articleshow/12035162.cms?from=mdr	H
32	Pottanthottam Vazhichal village, Neyyatinkara taluk, Thiruvanathpuram, Kerala	1988	Debris flows injured 4 persons and destroyed a house	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
33	Bali nala and Narsoo slide, J&K	1988	Road damaged on NH-1 (75 and 76 km from Jammu)	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
34	Market Colony, Zunheboto, Nagaland	1988	1 person was killed, houses destroyed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
35	Kinnaur	29-09-1988	Caused heavy loss of life and property in the Soldng village. Washed away the Bhabanagar water works. Washed away 2 km of NH-22 across Soldan Khad. Created landslides along the eastern slopes of Soldan Khad and damaged road to Ponda. Lake was formed on the Satluj river near conference. Block stopped the flow of Satluj river for about 30 minutes and created a temporary lake having dimensions roughly about 6000 m long. 200-250 m wide and 25-30 m deep extending up to Wangtoo Bridge. Lake water entered Sanjay Vidut Pariyojna and damaged the Power House	http://ddmakinnaur.hp.gov.in/page/History.aspx	H
36	Sapni slide, HP	10-11-1989	a section of road 730 metres in length was lost in a major landslide. The slide zone extended about the same distance up the hillside destroying sections of the Sapni link road and the head of the slide was within a few feet of the dogris at Shenaden	https://sci-hub.se/http://dx.doi.org/10.1111/1467-7717.00104	H
37	Jhakri, Himachal Pradesh	Mar-1989	Two major landslide occurrences took place at Nathpa, one on each side of Sutlej Valley. The one located on the left bank towards the lower hill, west of Nachar Village, is more commonly known as Nathpa slide.This landslide occurred in 1989, affecting an area of about 90,000 to 1,00,000sq.m of land. It damaged about 700m of road length of NH-22 at its base and more than 300m of hill slope. The slided boulders were quite big in size and their removal from the road required blasting. The slope failure process had created alarming situation and slide is still active in nature. Average width of the slide was about 280m to 300m, while from toe to crown; it was about 300-325m in length.	https://drsksingh.tripod.com/nathpaslide.pdf;http://ddmakinnaur.hp.gov.in/page/History.aspx	H
38	Syari and Deorali areas of Gangtok Town	16-09-1990	due to a heavy rainfall of 85 mm. There were nearly 25 deaths and considerable loss of properties especially of the army cantonment	http://rcin.org.pl/igipzContent/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
39	Geddhai landslide, Tamil Nadu	26-10-1990	36 deaths and several injured. Buildings, roads damaged and communication disrupted. Heavy rains had triggered an avalanche of	https://www.thehindu.com/news/cities/Coimbatore/geddhai-landslide-victims-remembered/article6534952.ece	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
			boulders at the Pegumballa Camp of the Tamil Nadu Generation and Distribution Corporation (Tangedco) in Geddhai just beyond Manjoor.		
40	Darjeeling town, Ging, Tukvor, Bennockburn, Bloomfield tea gardens and Pagla jhora and Chunabhati	15-09-1991 16-09-1991	2 people killed and the railway connection between hills and plains was damaged. It took almost 5 months to restore the railway connection between Darjiling and Siliguri.	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
41	Foot of Narkasur hill near Dispur, Guwahati	15-10-1991	15 persons killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
42	Gopeshwar, Chamoli	1991	36 killed and 26 livestock lost in 6 villages	http://usdma.uk.gov.in/PDFFiles/Traditional[1].pdf	H
43	Kinnaur, Himachal Pradesh	31-07-1991 to 02-08-1991	Cloudburst and flash flood along Soldan Khad in Satluj valley killed 32 people, 15 houses, 35 bigha agriculture land, 600 apple trees, 2km of road of NH 22 and 20 m bridge on Soldan Khad washed away. Agriculture land along Leo village situated downstream. Flood washed away 15 houses, 35 bigha of agriculture land and about 600 apple trees in Soldang village.	http://ddmakinnaur.hp.gov.in/page/History.aspx	H
44	Sihpui & Ramthar area, Aizawl	1991	70 houses were demolished	https://dmr.mizoram.gov.in/uploads/attachments c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	L
45	Koodaranji	01-07-1991	4 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
46	Assam	01-07-1991	300 deaths, damage of roads and buildings worth millions of rupees	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
47	Kappikalam (Padinjarethara	19-06-1991	11 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
48	Hlimen (located 7 km away from Aizawl)	09-8-1992	A total numbers of 22 houses were damaged along with 8 stone crushers and air compressors. The recorded life loss in this incident was 70 persons and the estimated value of the lost properties accounted for about Rs. 100 lakh. Recurred in 2005	file:///C:/Users/NIDM/Downloads/LANDSLIDE_AND_ASSOCIATE_ENVIRONMENTAL_PR.pdf	H
49	Aizawl landslide	1993, 2011, 2013	Landslide involving complete collapse of a stone quarry of 300m length and 250m thick at South Hlimen locality claimed 66 lives and 17 houses were destroyed. In 1993, Aizawl Venglai, Ramthar and Armed Veng localities were sinking, that caused severe damage to 65 houses.Since 1991, there was a long-line crack atbHunthar locality alongside Aizawl to Sairang road (National Highway 54), this road subsidence is recurrent in nature disturbing the main lifeline of the state In May, 2011, massive	https://dmr.mizoram.gov.in/uploads/attachmentsc5540f5242d78de7c680318d34f98b/mzsdmp-2020 -combined.pdf; http://ijiset.com/vol3/v3s1/IJISET_V3_I1_58pdf	
			"Ngaizel Landslide" stranded the national highway for many days.On 11 May 2013 , a rockslide occurred at the confluence of Laipuitlang and Ramhlun Venglai locality i.e at the eastern side of Aizawl, Mizoram-17 persons were died and 8 persons were rescued by the State Disaster Response Force. The rockslide completely destroyed 15 houses (7 RCC buildings and 8 Assam type buildings) including community hall and an evacuated 4 storeyed RCC building of Public Works Department (PWD) of Mizoram. Seventeen vehicles, including eight four-wheelers, have been buried under the debris		H
50	Mangpoo, Takdah, Pesoke, Rangtong, Tindharia, Pankhabari, Mahanadi, Gayabaari, Ambootia and Darjiling towns	11- 13 July 1993	Due to the occurrence of heavy and concentrated rainfall of 211.3 mm during 11th - 13th July, innumerable landslides and 15 people were killed in Mangpoo alone and damage to properties was quite severe	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
51	Adivaram (~100 slides)	06-10-1993	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
52	Jhakri, Himachal Pradesh	24-02-1993	On the right bank, a massive rock slide took place in the month of July, 1993, just upstream of the proposed dam axis, thereby blocking the river and raising it's water level which resulted in closure of existing upstream Bhaba power project situated 5kms upstream of proposed dam axis. The debris also blocked the proposed inlet of the Nathpa Jhakri diversion tunnel. The slide has upset the construction programme of the dam and also delayed the completion of the diversion tunnel.Satluj river blocked twice due to major landslide and rock fall near Jhakri and Nathpa, damaging NH-22	https://drsksingh.tripod.com/nathpaslide.pdf ; http://ddmakinnaur.hp.gov.in/page/History.aspx	H
53	Marappalam	11-11-1993	Nearly 40 deaths and property worth several lakhs damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
54	Kaki Khola,Sonpur Division,Tripura	10-05-1993	collapse of house, 6 person buried alive anda few injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
55	China Chip Village,Aizwal	20-06-1993	5 killed	https://www.researchgate.net/publication/322508425_Landslide_Inventory_of_India_1948_-_2017	L
56	Itanagar, Arunachal Pradesh	01-07-1993	25 deaths, 2 km road damaged and traffic disrupted	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
57	Kalingpong, West Bengal	05-08-1993	About 40 deaths and heavy loss to property	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
58	Kohima, Nagaland	17-08-1993	500 people died, several injured and about 200 houses destroyed; about 5km road stretch was damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
59	Urni, H.P.	21-08-1993	A jeep with its occupants was buried on H.T.road, 40 km from Shimla	https://www.researchgate.net/publication/322508425_Landslide_Inventory_of_India_1948_-_2017	L
60	Guwahati	09-06-1993	People affected due to flashfloods and landslides	https://www.researchgate.net/publication/322508425_Landslide_Inventory_of_India_1948_-_2017	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
61	Varundh Ghat, Konkan Coast	Jun-1994	20 killed, breaching of Ghat road upto 1km at several places	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
62	Bali Nala and Narsoo slide	01-01-1994	National Highway-1A badly damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
63	Bison valley	14-07-1994	7 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	M
64	Luggar Bhatti slide, Kullu, Himachal Pradesh	12-09-1995	65 people died at about 2km north of Kullu along left bank of Beas River	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
65	Malari, Jammu	Jun-1995	6 deaths and National Highway-1A badly damaged	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
66	Bas river in Kullu valley	4-5 and 12 Sept. 1995	Flood and landslide killed 65 people. NH damaged at numerous places, loss to government and private property, road and bridges estimated US$ 182 million.	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	H
67	Deorali, Gangtok	05-09-1995	30 people killed and huge damages to properties	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
68	Lawngtlai & Saiha town area	May 16 & 17, 1995	Totalling 360 mm of rain. Human casualty - 34, injured-6, fully damaged house - 270, severely damaged houses- 467	-	H
69	Gangtok and its suburbs, Chandmari, tathangchen, Zero point, Gangtok Bhusuk Road	08-06-1997	50 people killed and damaged large number of houses. Killed a constable on duty and destroyed the institute of cottage industries and numerous vehicles. About 20 minor and major landslides occurred. In Changey Tar Basty, 1 dies and several houses and other properties destroyed	http://rcin.org.pl/igipz/Content/110/WA51_215_r2003-vol76-no2_Geogr-Polonica.pdf	H
70	Pazhampallicha	21-07-1997	9 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	M
71	Ozhuvathadam	21-07-1997	2 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
72	Valara	21-07-1997	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
73	Cheeyappara	21-07-1997	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
74	Andhra khad in Pabbar valley	11-08-1997	Flash flood and landslide killed 124 people, 456 cattle, washed away government and private buildings, 200 m road section and damaged Andhra power house at Chirgaon. Loss was estimated Rs. 10.63 million.	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	H
75	Malpa Landslide, Kali River	17/18-08 1998	Wiped out Malpa village with >210 persons killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
76	Chandighat Tea Estate, Assam	04-06-1998	22 persons killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
77	Gangtok and its suburbs	06-06-1998	65 houses badly damaged and other 118 partially damaged	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	M
78	Gangtok and its suburbs	13-06-1998	3 persons died and 4 injured on 13 June in Ranipool when a multistory house collapsed. Subsidence of Bakthang-Burtuk slide. Gurdum slide collapsed the Samdong Highway. Basement of a house at 7th mile, Samdur washed away, resulting in collapse of a house and a temple at Ranipool	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
79	Ukhimath Landslide blocked Madhyamaheshwar river (tributary of Mandakini)	11-08-1998 to 12-08-1998	109 deaths and 1908 families from 29 villages affected and 820 houses damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
80	Madhya Maheshwar, Rudraprayag	17-08-1998	40 persons killed and 10 livestock lost	http://usdma.uk.gov.in/PDFFiles/LANDSLIDEHAZARD.pdf	H
81	Barua Bhenti slide UK	19-09-1998	15 people died, several livestock killed at about 8 km north of Okhimath along the left bank of Madhmaheshwar river	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
82	Idichakkaplamoodu (Trivandrum-Nagercoil railway line)	15-11-1998	3 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
83	Pamba	15-01-1999	25 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
84	Garhwal region of Western Himalayas	29-03-1999	In March 1999 moderate earth quake, measuring 6.8 on Richter scale. After earthquake 338 landslides were mapped in the surrounding regions. Most of the landslides were shallow slides with weathered bed rocks There were 103 causalities mainly due to earthquake	https://www.researchgate.net/publication/281546724_Chamoli_earthquake_of_29th_March_1999_Garhwal_Himalaya_India_An_observation/citations	H
85	Kinnaur	12-07-2000	At least eight persons, including two policemen, were killed in a massive landslide	https://www.tribuneindia.com/2000/20000713/main1.htm	M
86	Ghatkopar area, Mumbai, Maharastra	12-07-2000	67 people were killed	https://www.freepressjournal.in/cmcm/on-this-day-in-history-july-12-2000-landslide-caused-by-heavy-rains-kills-67-people-in-mumbais-ghatkopar-area	H
87	Shimla	17-07-2000	Four children were injured seriously when a portion of their school building collapsed at Guggaghat, about 6 km from here, following heavy down-pour. Traffic on the Kalka-Shimla national highway and most link roads remained blocked for long hours following huge landslides. Though traffic, remained suspended for over five hours when a landslide struck the national highway near Mandsar village, about 8 km from here. Traffic also remained suspended for nearly two hours near Jabli where several landslides blocked the Kalka-Shimla road below the Cosmo Ferrities factory. Hundreds of vehicles with over, 5,000 passengers remained stranded during the road blockade.	https://www.tribuneindia.com/2000/20000718/main6.htm	H
88	Chundakkadu (Nelliyampathi)	25-08-2000	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
89	Cheenikuzhi	09-07-2001	3 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
90	Amboori village	09-11-2001	38 people died and 4 houses destroyed, damaged rubber plantation	https://www.researchgate.net/publication/292518478_Causes_and_mechanism_of_Amboori_landslide_of_9th_November_2001_Thiruvananthapuram_district_Kerala	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
91	Dharchula	27-07-2001	5 killed	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
92	Phata and Byung Gad Landslides, Chamoli	17-07-2001	21 killed and several houses damaged	https://www.researchgate.net/publication/209804820_The_catastrophic_landslide_of_16_July_2001_in_Phata_Byung_area_Rudraprayag_District_Garhwal_Himalaya_India	H
93	Ukhimath, Rudraprayag	16-07-2001	28 persons killed	https://www.researchgate.net/publication/263215192_Ukhimath_landslide_2012_at_Uttarakhand_India_Causes_and_consequences	H
94	Kalimandir, Hatigarh, Assam	01-06-2001	1 killed, 1 injured	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
95	Bhaskarnagar, Hatigarh, Assam	01-06-2001	2 killed, 1 injured, wall collapsed	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
96	Kalapahar, Assam	01-06-2001	1 killed and 1 injured	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
97	Chunsali hill, Assam	01-06-2001	1 killed	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
98	Gurpisey Landslide	2001	Landslide took place in 2001 due to heavy downpour. Five houses (two newly constructed buildings and three traditional houses) totally distraction of slope. No life was lost but an old lady was highly injured. The disaster relief team admitted her to hospital. Sudden supply of huge water discharge due to heavy and concentrated rainfall within a very short period of time exerted enormous amount of pressure in the fissure and initiated the landslide which was gradually enhanced along the unstable wet and slippery slope	https://www.researchgate.net/publication/337759257_A_Geomorphological_investigation_of_Gurpisey_Landslide_in_Eastern_Himalayas_Namchi_South_Sikkim	L
99	Venniyani mala	09-07-2002	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
100	Kangni nalla near Solang in Kullu district	07-08-0203	30 people lost their lives and 19 people were injured and 9 people are missing, 2 people lost their lives due to landslide in Bhang nalla.	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	H
101	Budhakedar and Khetgaon Landslide, Bal Ganga Valley, Tehri	10-08-2002	29 people killed	http://covid19usdma.uk.gov.in/PDFFiles/21-Article%20Text-237-2-10-20200802.pdf	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
102	Chumekedima, Phiphima and Lalmati in Nagaland and between Mao and Tadubi in Manipur	12-08-2002 to 14-08-2002	National Highway 39 cut off Nagaland and Manipur from the rest of the country. Following the landslides, at least 200 trucks and 100 passenger buses have been stranded at various points on the highway. Prices of essential commodities have sky-rocketed in both Kohima and Imphal.	https://www.rediff.com/news/2002/aug/14ne.htm	H
103	Varunawat Landslide, Uttarkashi, Uttarakhand	23-09-2003	About 400 houses/shops affected	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	H
104	Manpur Khola slide, south Sikkim	Sep-2003	4 killed, kholaghari bridge washed away, massive flash floods	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	M
105	Darjeeling, West Bengal	July, 2003	11 people were killed, 5 houses destroyed and 6 people were missing, when heavy rains lashed the eastern Indian hill station of Darjeeling as on July 8, 2003	https://www.researchgate.net/publication/286642064_Causes_and_consequences_of_landslides_in_the_Darjiling-Sikkim_Himalayas_India	H
106	Kaithapadam Thooveri Parambil (Pottammel-Palazhi Road)	06-06-2004	2 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
107	Nittukottamala	10-08-2004	10 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	H
108	Amparaav Landslide	23-09-2004	3 killed, 7 shops damaged, >300m bridle path destroyed, 29 families affected due to land loss	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.694.8153&rep=rep1&type=pdf	H
109	Durgasarobar, Guwahati	Jul-2004	5 persons died, 6 houses damaged	http://www.joegindia.com/PAPER/VOL-36/PAPER-38%20C%20D%20SINGH.pdf	L
110	Armed Veng, Aizawl	2004	98 families vulnerable in sinking area	https://www.researchgate.net/publication/345776004_Vulnerability_of_Landslide_Disaster_in_Aizawl_City	M
111	Ngopa village, Mizoram	2004	45 buildings and 55 families were affected	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp -2020-combined.pdf	M
112	Chandmari west, Mizoram	2005	30 houses vacated	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	L
113	Manzing slide, South Sikkim	24-09-2005	7 killed and 28 families evacuated	https://www.yumpu.com/en/document/view/46711524/landslides-hazards-zonation-map-of-india-south-sikkim	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
114	Maligaon Petrol Pump, Nilachal Hill, Assam	24-08-2005 to 25-08-2005	12 persons died, injured many and caused heavy damages to buildings and huts	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.694.8153&rep=rep1&type=pdf	H
115	Govindghat, Joshimath	Aug-2005	11 killed	https://www.longdom.org/open-access/landslide-distribution-and-damages-during-2013-deluge-a-case-study-of-chamoli-district-uttarakhand-2167-0587-1000226.pdf	H
116	Vellikulangara	Jul-2005	2 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
117	Vijaynagar, Rudraprayag	26-07-2005	9 killed	https://www.longdom.org/open-access/landslide-distribution-and-damages-during-2013-deluge-a-case-study-of-chamoli-district-uttarakhand-2167-0587-1000226.pdf	H
118	Anthoniar Colony (Munnar)	27-07-2005	4 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
119	Dasgaon slide, Raigad distt, Mahatrashtra	26-07-2005	Villages of Mahad taluka of Raigad district like Jui, Rohan, Dasgaon, Kondivite, Chochinde, Muthvali, Khaire, Valang, Tudil, Sav villages were seriously affected by landslides. Due to these landslides, about 190 people lost their life and caused damages to agricultural field, settlement (over 400 houses) and civic infrastructures	https://www.researchgate.net/publication/237597471_Disastrous_landslide_episode_of_July_2005_in_the_Konkan_plain_of_Maharashtra_India_with_special_reference_to_tectonic_control_and_hydrothermal_anomaly	H
120	Mokokchung Debris Avalanche	26-05-2005	14 persons killed, 50 injured, 4 houses destroyed and 35 damaged	https://morungexpress.com/landslide-hazard-zonation-mapping-nagaland	H
121	Jammu & Kashmir	08-10-2005	Earthquake-triggered landslides destroyed many houses on hillsides and blocked roads. 80,000 deaths were reported	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
122	Samroli area in Udhampur-Kud sector	08-07-2007	The Jammu - Srinagar National Highway was closed to traffic on Sunday after landslides triggered by heavy rains blocked it at Samroli, 80 kms from here, leaving thousands of vehicles stranded including those carrying Amarnath pilgrims. Landslides caused by rains in Samroli area in Udhampur-Kud sector forced closure of the highway	https://timesofindia.indiatimes.com/india/jammu-srinagar-highway-closed-after-landslide/articleshow/2186126.cms	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
123	Khabbak Village, Samba Tehsil, Jammu	16-02-2007	One person was killed and three were injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
124	Jammu Srinagar NH	22-02-2007	Highway closed, >100 vehicles stranded	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
125	Doda District, Jammu	18-03-2007	2 killed, 5 injured/missing	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
126	Wayanad, Kerala	15-06-2007	5 killed, 2injured/missing, 265 houses and crop lost amounting to economic loss of Rs.8.5 Lakh and 6.5 Crore	http://citeseerx.ist.psu.edu/viewdocdownload?doi=10.1.1.694.8153&rep=rep1&type=pdf	M
127	Wayanad district, Kerala.	07-07-2007	during the south-west monsoon in Erumakolli tea estate near Meppadi in Wayanad district, Kerala the landslide ruined two houses and damaged several houses. The landslide also caused widespread damage to property. Subsidence and piping also occurred in this area.	https://link.springer.com/article/10.1007%2Fs11069-014-1342-x#citeas	M
128	Gangtok Amdogolai	15-06-2007	A huge boulder slipped all of a sudden at Amdo Golai in the morning of June 13. Huge boulders from a hill next to the traffic point at Amdo Golai, about two km from here, came tumbling down on the bypass injuring traffic constable and blocking traffic along the route. The massive damage and blockade on roads again on saturady June15 an 16.	http://sikkimnews.blogspot.com/2007/06/gangtok-amdogolai-landslide-slips-again.html	L
129	Purli village, Hamirpur-Kakker road, HP	23-06-2007	Three persons were killed and three injured when a portion of a hillock came down sliding on the Tohni Devi- Kakkar road, around 32 km from Hamirpur.	https://www.tribuneindia.com/2007/20070624/himachal.htm#9	M
130	Valathodu in Wayanad district	23-06-2007	Four members of a family were buried alive	https://www.oneindia.com/2007/06/23/landslide-kills-four-people-1182582285.html	L
131	Banihal	25-06-2007	3 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
132	Chembur, Mumbai	25-06-2007	2 killed	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	L
133	Taktse area of Bojhoghari in Gangtok	27-06-2007	2 killed and few houses washed away.	10.1080/19475683.2019.1575906	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
134	Uttarkashi district	26-06-2007	One person has died and more than 250 families of Uttarkashi town evacuated. More than 44 residential buildings and 39 commercial establishments, including the district collectorate, were hit by the mudslides.	http://archive.indianexpress.com/news/landslides-in-uttarkashi-one-dead/202776/	M
135	Calcutta, West Bengal	03-07-2007	8 killed	http://citeseerx.ist.psu.edu/viewdoc/download?doi= 10.1.1.694.8153&rep=rep1&type=pdf	M
136	Doda District, Jammu	10-07-2007	2 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
137	Kurseong, Darjeeling, WB	15-07-2007	2 houses damaged and NH-55 road link broken	https://www.oneindia.com/2007/07/15/landslides-cut-off-darjeeling-and-kurseong-towns-houses-damaged-1184495935.html?utm_medium=Desktop&utm_source=OI-EN&utm_campaign=Topic-Article&story=2	M
138	Kairadi	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
139	Mysoorpetta-Thottamukam	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
140	Panakkachal	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
141	Anayode	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
142	Alappara	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
143	Edavanna	17-07-2007	2 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
144	Kavalupara	17-07-2007	1 died	https://link.springer.com/content/pdf/10.1007/s00254-008-1431-9.pdf	L
145	Thiruvanantha-puram, Kerala	17-07-2007	8 killed	https://www.rediff.com/news/2007/jul/17rain.htm	M
146	Bhavi Village, Ghanvi, Shimla	15-08-2007	58 persons died; All roads leading to village cut off	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	H
147	Baram village in Uttarakhand's Pithoragarh	06-09-2007	Five persons were killed and nine others were feared dead	Five killed in landslides in Uttarakhand | India News - Times of India (indiatimes.com)	M
148	Mamit District	Sept, 2007	Many landslides throughout Mamit District blocking NH-44A for 13 days	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
149	Ganderbal, Srinagar	17-12-2007	2 died 6 injured, temple, bridge and army bunker damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
150	Poonch J&K	08-01-2008	1 died, 850 vehicles stranded	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
151	Srinagar	09-01-2008	200 vehicles stranded	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
152	Udhampur	10-01-2008	15 died	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
153	Ramban, Banihal	08-02-2008	3 died 15 injured, 400-500 trucks stranded	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
154	Uri	18-02-2008	1 died	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
155	Qazigund	31-03-2008	2 died and 1 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
156	Kathua	02-05-2008	8 died several went missing	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
157	Leh	26-10-2008	2 died and 32 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
158	Kishtwar district	26-11-2008	6 died	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
159	Pithoragarh district	08-08-2009	45 died	https://public.emdat.be/data	H
160	Cachar distt, Assam	09-01-2009	1 killed, 1 injured		L
161	Srinagar	06-02-2009	4 died	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
162	Naharlagun, Arunachal	01-05-2009	4 died, 2 injured	https://sdma-arunachal.in/history-of-vulnerability-of-the-state-to-the-disasters-of-different-types/	L
163	Gurez	17-06-2009	1 died, 4000 pilgrims stranded	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
164	Kurseong, Darjeeling	26-05-2009	15 people were killed and 21 injured	https://www.outlookindia.com/newswire/story/15-killed-in-landslides-in-darjeeling/660442	H
165	Mainpuri and Pilibhit distt, UP	27-05-2009	8 killed		M
166	Kurseong, Darjeeling	28-05-2009	27 killed, 500 houses damaged	https://www.hindustantimes.com/india/darjeeling-landslide-toll-reaches-27/story-K8flQ5n7JEdJqDARoOpv5M.html	H
167	Berhampur, Orissa	28-01-2009	2 killed, 2 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
168	Pune - Mumbai Expressway	30-06-2009	1 killed, 5 injured	https://timesofindia.india-times.com/city/pune/e-way-landslide-leaves-1-dead/articleshow/4718144.cms	L
169	Pitthoragarh distt.	30-06-2009	5 killed	https://www.omicsonline.org/open-access/disastrous-events-on-kelashmansarowar-route-dharchula-tehsil-in-pithoragarh-district-uttarakhand-in-india-2157-7617-1000463-100748html	L
170	Kalimpong-Darjeeling	04-07-2009	1 killed, Darjeeling and Sikkim cut-off from the country	https://www.researchgate.net/publication/299492216_Landslides_and_Floods_in_the_Tista_Basin_Darjeelin_and_Jalpaiguri_Districts_Historical_Evidence_Causes_and_Consequences	L
171	Kalwa, ThaneMumbai	12-07-2009	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
172	Wayanad, Kerala	17-07-2009	2 injured, 46 houses destroyed and agricultural land also	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
173	Pittoragarh	21-07-2009	3 killed, 1 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
174	Gopeshwar, Chamoli	26-07-2009	2 killed, 4 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
175	Vaishnodevi cave shrine in Reasi	29-07-2009	The person killed was a woman pilgrim and two others were injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
176	Kupwara	29-07-2009	3 killed and Tourism affected killing three pilgrims	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
177	JN Marg, 17th Mile, Kyongsala, Gangtok	01-08-2009	1 killed (BRO labourer), tourist spot completely destroyed	http://sikkimnews.blogspot.com/2009/08/land-slides-at-17th-mile-cut-off-tsomgo.html	L
178	Tenga, Arunachal	02-08-2009	1 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
179	Atholi, Kishtwar	02-08-2009	1 died, 2 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
180	Amarnath	02-08-2009	2 died	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
181	Dharampur, Mandi	07-08-2009	2 died	http://hpenvis.nic.in/Database/HazardProfileofState_4178.aspx?format=Print	L
182	Nachni, Pitthoragarh	08-08-2009	43 killed, 3 Villages Nachni, La and Jhekla were completely buried under landslides	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
183	Kurseong, Darjeeling	16-08-2009	9 killed, 2 injured, 500 houses damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
184	Champawat distt, UK	17-08-2009	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
185	Pitthoragarh	17-08-2009	1 killed		L
186	Kurseong, Darjeeling	20-08-2009	3 killed, 10 injured, NH-31A blocked	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
187	Sombaria and Daramdin, West Sikkim	20-08-2009	2 persons killed and 10 injured. Scores of houses including government buildings were damaged. Cattle and standing crops washed away. Sikkim was cut- off for 20 hours after landslide blocked highway b/n Sevoke and Rambi near Siliguri	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
188	Pitthoragarh	28-08-2009	1 killed	https://www.unisdr org/ prevention web/files/39114_39114biblio graphylandslide1.pdf	L
189	Almora distt	02-09-2009	2 killed	https://www.unisdr.org/preven tionweb/files/39114_ 39114 biblio graphy landslide1.pdf	L
190	Mumbai	05-09-2009	10 died and 13 injured. Around 10 houses at the Lal Bahadur Shastri Nagar slums were buried.	https://mumbaimirror.indiatimes.com/mumbai/other/10-die-in-sakinaka-landslide/articleshow/15951888.cms	H
191	Vaishno Devi	23-09-2009	3 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
192	Madibagh of Kadwad in Karwar taluk, Uttara Kannda distt, Karnataka	02-10-2009	24 killed, 9 houses collapsed, NH-17 blocked. In total 21 landslide occurred on that day in Karwar hills	http://wgbis.ces.iisc.ernet.in/biodiversity/pubs/ETR/ETR33/section2.htm	H
193	Aizawl, Mizoram	06-10-2009	3 killed 10 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
194	Kodaikanal, TN	16-10-2009	1 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
195	Ujire, Dakshin Kannada	26-10-2009	1 killed, 2 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
196	Keonjhar distt, Orissa	29-10-2009	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
197	Udhagamandalam, TN	08-11-2009	5 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
198	Udhagamandalam (Ooty), TN	10-11-2009	43 killed, 600 houses destroyed, 1100 people homeless	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
199	Parimal Garden underpass, Ahmedabad	21-11-2009	5 killed, 1 injured	https://timesofindia.indiatimes.com/city/ahmedabad/5-die-as-wall-collapses-at-parimal-underpass/articleshow/5252737.cms	L
200	Keran Sector, Kupwara	12-12-2009	1 person killed was a BRO porter	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
201	Kishtwar	12-12-2009	1 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
202	Reasi	03-01-2010	Landslides triggered due to heavy rains injured one pilgrim	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
203	Vaishno Devi	03-01-2010	1 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
204	Kupwara district	09-01-2010	4 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
205	Vaishno Devi	08-02-2010	17 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
206	Kishtwar	08-02-2010	1 killed and 6 injured, 5 houses damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
207	Gulmarg	10-02-2010	3 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
208	Kinnaur, HP	14-02-2010	6 killed, 14 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
209	Chairvani Village, Ganderbal	22-02-2010	6 killed 6 injured in Chairvani Village, Ganderbal District	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
210	Uri	22-02-2010	1 killed and 6 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
211	Tehri distt	23-02-2010	2 killed, 1 injured, 1 house demolished	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
212	Reasi	27-02-2010	Casualty of two pilgrims. Location of landslide at Hathi Matha, in Reasi district triggered due to heavy rains	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
213	Siachen Glacier	27-02-2010	2 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
214	Imphal, Manipur	27-03-2010	1 house damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
215	Kurung Kumey distt, Arunchal	02-04-2010	7 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
216	Paglanala-1, Paglagaon, Cachar distt, Assam	02-04-2010	3 killed, 2 injured, 1 house demolished	https://reliefweb.int/sites/reliefweb.int/files/resources/Cachar.pdf	L
217	Zojilla Village	20-04-2010	Incessant rains caused landslides at many places on Srinagar-Ladakh highway and the highway was closed due to landslides at Zojilla	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
218	JN Marg stretch, East Sikkim	21-04-2010	Multiple landslide resulted in road disruption and telephone communication. 250 vehicles and 1500 tourists including women and children stranded on JN Marg near Mathual. Rescued by Army	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
219	Khowal and Teliamura, Tripura	22-04-2010	4 killed, 1 house destroyed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
220	Dibang valley, Arunachal	22-04-2010	12 killed, communication lines cut off	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	H
221	Gayabari, Darjeeling	24-04-2010	Toy train link severely damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
222	Srinagar-Leh National Highway	28-04-2010	Heavy rains caused landslide along the Srinagar -Leh national highway, killing a BRO laborer	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
223	Gandarbal, Srinagar	28-04-2010	1 died Srinagar-Leh highway closed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
224	Srinagar-Leh National Highway	17-05-2010	The traffic on the 434-km Srinagar-Leh national highway was suspended after heavy landslides occurred at Captain Mode, 100 km from Srinagar and other places on the highway due to incessant rain for the past one week	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
225	Batote - Kishtwar Highway, Doda	18-05-2010	Landslide triggered during widening of road stretch at Ragi Nallah, about 150 km from Jammu, on Batote - Kishtwar highway in Doda district led to the closure of the highway	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
226	Leh-Karu-Tangtse axis in Ladakh	18-05-2010	2 died and Location two km short of the 17,350 ft Chang La top on Leh-Karu-Tangtse axis in Ladakh region. The Indian Army rescued 73 trapped people	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
227	Vaishno Devi	18-05-2010	2 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
228	Leh	20-05-2010	1 Army personnel was killed, hit by a heavy boulder during the landslide. Location near Siachen base camp Nobra, about 500 km from Srinagar, in Leh district	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
229	Srinagar	20-05-2010	1 killed	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
230	Chadiyan village Baramulla	25-05-2010	Several houses damaged. Affected Chadiyan village located on a mountainous slope near the border town of Uri in Baramulla district	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
231	Ladakh	26-05-2010	20 houses damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
232	Turtuk area of Nubra valley	27-05-2010	A school bus with 15 children on board was trapped and army personnel evacuated them		L
233	East Sikkim and North Sikkim	31-05-2010	Road cut off b/n Tsomgo and Nathual in Sikkim. The alternate highway to North Sikkim via Singtham in East Sikkim was also blocked due to multiple landslide on 31 May	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
234	Rongpur-1, Rongpur village, Karimganj distt, Assam	03-01-2010	2 killed 5 injured, mudhouse totally damaged burying the whole family	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
235	Sumin, Kamarey, Padamchey villages of Pakyong subdivision, Rongli subdivision, Singtham Gangtok. Lower Namphiang Basty, East Sikkim	03-06-2010	Damed 20 houses besides burying standing crops, livestock and disrupting road connectivity. A bridge was damaged by slides disrupting Rangpo-Rhenock Rongli traffic. Road to Dickling completely blocked. Water pipe damaged causing water supply problem. Singtham-Makha Road, Ravangla Singtham and Gangtok-Namchi road was largekly affected	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
236	Baramulla distt, J&K	04-06-2010	1 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
237	Dhalai distt, Tripura	06-06-2010	5 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
238	Uri, J&K	06-06-2010	6 killed, traffic disrupted	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
239	Antop hill, Mumbai	09-06-2010	2 killed, 1 injure	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
240	Kalimpong, Darjeeling	16-06-2010	3 killed 2 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
241	Pegong, North Sikkim	16-06-2010	8 killed, 2 houses damaged	http://kalimpongonlinenews1.blogspot.com/2010/06/press-freedom-day-in-sikkim-gangtokthe.html	H
242	Jatinga-Harangajao Railway slide	16-06-2010	Railway traffic disrupted for 4 hrs	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
243	Ratnagiri, Maharashtra	19-06-2010	Road to Lachung completely cut off	https://www.indiatoday.in/latest-headlines/story/ten-killed-in-ratnagiri-landslide-76943-2010-06-19	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
244	Valmikinagar, Kurla, Mumbai	25-06-2010	5 houses damaged	https://indianexpress.com/article/cities/mumbai/5-houses-damaged-in-landslip/	L
245	Shillong	28-06-2010	A 14-year-old girl was killed and at least seven others were injured after heavy rains triggered a landslide in Shillong.	https://www.hindustantimes.com/india/girl-dies-in-landslide-flash-flood-wrecks-havoc-in-meghalaya/story-2U0pzgDBkxGZ5N67rqKuaM.html	L
246	Tingda, North Sikkim	14-06-2010	Blocked the Mangan-Gangtok highway	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
247	Nainital	20-07-2010	1 killed	https://www.tribuneindia.com/2010/20100720/dplus.htm	L
248	Almora distt	22-07-2010	1 killed	https://www.unisdr.org/ preventionweb/files/39114_ 39114 bibliography landslide1.pdf	L
249	New Mhada Colony near Nagari Nivara in Dindoshi, Malad, Mumbai	22-07-2010	6 houses damaged, 6 families made homeless	https://timesofindia.indiatimes.com/city/mumbai/landslide-ruins-row-houses/articleshow/6208392.cms	L
250	Ratnagiri, Maharshtra	24-07-2010	Konkan railway services collapsed, 5000 passengers stranded, Mumbai-Goa highway blocked	https://www.indiatoday.in/india/west/story/landslide-halts-konkan-railway-traffic-passengers-stranded-79317-2010-07-26	M
251	Kanlog area, Shimla	25-07-2010	2 killed, 3 injured, several houses collapsed	https://indianexpress.com/article/cities/chandigarh/two-dead-as-heavy-rains-cause-landslides-in-shimla/	L
252	Ramban	25-07-2010	Landslide triggered by heavy rains near Panthal between Ramban and Ramsu blocked the Jammu	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
253	Shaktinagar, Mangalore	29-07-2010	Damaged house and injured a person	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
254	Uttarkashi	30-07-2010	9 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
255	Amboli ghat in Sindhudurg, Maharashtra	30-07-2010	Massive damage at Ambolighat, rail tracks damaged	https://www.team-bhp.com/forum/route-travel-queries/41285-monsoons-road-condition-update-15.html	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
256	Milind nagar slums and Ghatkopar, Mumbai	31-07-2010	Dozen dwelling units damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
257	Sliyapadavu of Amblamogaru gram Panchayat	01-08-2010	>30 houses developed cracks due to landslide	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
258	Chamoli district	05-08-2010	Five members of a family were killed in their sleep when their house, situated near Gauchar Polytechnic in Chamoli district, was buried under the debris of a landslide	https://www.tribuneindia.com/2010/20100806/dplus.htm#2	L
259	Gayabari, Darjeeling	06-08-2010	The traffic along the National Highway 55 was disrupted following a heavy rainfall that triggered landslide in the Darjeeling Hills valley region	https://www.oneindia.com/ 2010/08/07/heavyrainfall-triggers-landslide-blocks-traffic-on-nh55.html	M
260	Chang-la pass, Ladakh	06-08-2010	145 died. The flash floods and mudslides triggered by cloudburst at Leh on 5th and 6th August 2010 destroyed more than 50 houses. Several villages along the Chang-la pass and stretches of road washed away. Apart from reported casualties, several people went missing	http://jtfrp.in/wp-content uploads 2019/01/JK_Data-inventory Report _ 30Nov2018-RMSI.pdf; https://reliefweb.int/sites/reliefweb.int/ files/resources/EF226EE178CC9209C12577A40030B2D2-Full_report.pdf	H
261	Mamit, Mizoram	06-08-2010	3 houses damaged, 10 houses and shops declared unsafe	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
262	Mamit & Ngopa Town	09-08-2010	Mamit Town – 65 houses destroyed/dismantled. Ngopa town – 10 houses destroyed/dismantled.	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	M
263	Uri	10-08-2010	1 killed and 7 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
264	Solan distt, HP	14-08-2010	2 killed, 1 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
265	Sakinaka andheri - Mumbai	17-08-2010	1 injured	https://timesofindia.indiatimes.com/city/mumbai/1-dead-2-trapped-in-mumbai-landslide/articleshow/6325312.cms	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
266	Tintek Khola on road from Singtham via Dikchu to Mangan, East Sikkim	19-08-2010	Blocked the Singtham - Mangan Highway	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
267	Shumgarh Landslide, Bageshwar distt	18-08-2010	18 school student between 5 and 12 years of age were buried alive, 12 injured, whole school destroyed	http://archive.indianexpress.com/news/18-children-killedas-school-roof-collapses-in-uttarakhand/662092/	H
268	Sainik Nagar, Kausa.	21-08-2010	6 killed 2 injured	https://mumbaimirror.indiatimes.com/mumbai/other/fate-deals-cruel-blow-as-couple-with-three-paralysed-kids-loses-home-in-landslide/articleshow/16045670.cms	M
269	Syat village, near Kotabagh Nainital	22-08-2010	A major tragedy at Syat village, near Kotabagh, was averted as children of a Navodaya Vidyalaya had gone home on account of the holidays being declared on account of the weather condition. A major landslide damaged the school hostel which otherwise would have had the presence of more than 200 children.	https://www.tribuneindia.com/2010/20100823/dplus.htm#2	L
270	32 Mile and Singtham on NH-31A	27-08-2010	7 landslides struck at 15km stretch of NH-31A and crippled traffic. A 31 year old woman was washed away in one of the flash floods that followed. The first major landslide was at the mouh of Topakhani, a 12 m tunnel	https://www.indiamike.com/india/india-travel-news-and-commentary-f80/landslides-in-sikkim-27th-august-2010-a-t116523/#post1032601	H
271	Gangtok	28-08-2010	4 buildings damaged, 38 families shifted	http://savethehills.blogspot.com/2010/08/	M
272	Prakasam distt, AP	01-09-2010	1 school building destroyed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
273	Brahamanand Reddy Nagar in Machavaram, AP	01-09-2010	4 houses collapsed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
274	Ghulam Mohiuddin Nagar, AP	01-09-2010	3 houses collapsed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
275	Chittinagar, AP	01-09-2010	3 houses collapsed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
276	Jeori in Shimla district, Himachal Pradesh	06-09-2010	Shimla-Kinnaur national highway closed after massive landslide at Jeori. No loss of life reported.	https://twitter.com/nagarkoti/status/1434748521400336387?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1434748521400336387%7=Ctwg%5E%7Ctwcon%5Es1_&refurl=https%3A%2F%2Fblogs.aguorg%2Flandslideblog%2F2021%2F09%2F07%2Fjeori-1%2F	M
277	Pitthoragarh	06-09-2010	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
278	Leh	07-09-2010	2 killed and 1 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
279	Rudraprayag	08-09-2010	1 killed	https://nidm.gov.in/PDF/pubs/uttarkashi.pdf	L
280	Dhemaji, Golaghat and Bongaigaon, Assam	12-09-2010	2 killed, 300,000 displaced in floods and landslides	http://asdma.gov.in/pdf/asdmp.pdf	H
281	Nahan, HP	12-09-2010	1 killed, house collapsed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
282	Taikual, Aizawl	13-09-2010	1 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
283	Ri Bhoi district, Meghalaya	15-09-2010	Economic loss of ~Rs.60 Lakh	https://assamtribune.com/death-toll-rises-to-6-in-meghalaya-landslides;https://www.researchgate.net publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
284	Almora District of the Kumaun Lesser Himalaya	18-09-2010 to 19-09-2010	43 killed Estimate Cost of Damages Indian Rs. 6,231,056.000 (US$:125, 771,000)	https://journals.openedition.org/belgeo/6311?gathStatIcon=true&lang=nl	H
285	Joshimath, Chamoli	22-09-2010	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
286	Shimla	23-09-2010	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
287	Kangra	23-09-2010	2 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
288	Kinnaur	23-09-2010	3 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
289	Kishtwar	03-10-2010	Casualty of 3 army personnel		L
290	Upper Siang Distt, Arunachal	04-10-2010	10 killed (8 killed in house collapse in Mosing village), houses buried	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
291	Rohtang Pass, HP	22-10-2010	1 killed, Leh-Manali road closed, 2500 tourists stranded 500 tourists were evacuated after 30 hours while others were rescued in 12 hours	https://timesofindia.indiatimes.com/india/tourists-walk-into-snow-trap-in-rohtang/articleshow/45516887.cms	H
292	Uri district	23-10-2010	Casualty of 3 army personnel. Landslides, triggered due heavy rains, hampered traffic movement	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
293	Poochapra, Iddukki, Kerala	30-10-2010	3 killed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
294	Karwar, Uttara Kanada distt.	08-11-2010	1 killed, 14 injured, Mangalore-Mumbai-Matsyagandha Express damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	H
295	Doda	12-02-2011	2 killed and 1 injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
296	Ramban	14-02-2011	About 1,200 vehicles stranded as Jammu-Srinagar highway was closed for traffic after flash floods and heavy rains triggered landslides in Ramban District and damaged the highway	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
297	Kamrup distt., Assam	18-02-2011	2 killed, 1 injured	https://nidm.gov.in/PDF/pubs/EQ%20North%20East.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
298	Manali	26-02-2011	Collapsed terraced fields, uprooting and falling of trees, disrupting vehicular traffic at Raison, Dobhi, Alu Ground, Rangri and Manali.	https://cdn.s3waas.gov.in/s368d30a9594728bc39aa24be94b319d21/uploads/2018/07/2018070980.pdf	M
299	Manali	05-03-2011	Roads were blocked, electricity Supply dismantled, a four story traditional house collapsed due to weight of four-foot snow in Malana village	https://cdn.s3waas.gov.ins368d30a9594728bc39aa24be94b319d21uploads/2018/07/2018070980.pdf	M
300	Uri	04-03-2011	1 died, Four houses damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
301	Kharguli, Guwahati	23-03-2011	5 killed, 4 injured	https://timesofindia.indiatimes.com/city/guwahati/five-die-in-kharguli-landslide/articleshow/7775498.cms	L
302	Kurseong, Darjeeling	27-03-2011	2 killed, 2 injured	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
303	Shaptashrungi Temple, Vani, Maharashtra	16-04-2011	an old woman died due to rockfall at SGT hill when she was performing parikrama and also two persons injured during the rescue process of the old women from the continuous rockfall activity	https://www.researchgate.net/publication/289344339_Rockfall_hazard_assessment_at_saptashrungi_gad_temple_sgt_vani_nashik_maharashtra_india	L
304	Phimram Shangus	18-04-2011	All the 5 killed were of one family and another person was injured by this landslide triggered by heavy rain	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
305	JN Road and Sichey, Gangtok	02-05-2011	3 power distribution of substation damaged, protection walls Cut off electricity in the villages of Sichey for few days	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	M
306	Karimganj distt, Assam	04-05-2011	2 killed, 2 injured & 1 house damaged	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
307	Uttarkashi	01-06-2011	1 killed, Risheskesh-Yumnotri NH closed	https://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_India	L
308	Kishtwar	09-06-2011	8 shops & 10 kiosks destroyed, dozen vehicles damaged	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
309	Kurseong, Darjeeling	17-06-2011	4 killed, 1 house damaged	https://www.thehindu.com/news/national/other-states/four-die-in-landslide-in-darjeeling-hills/article2112556.ece	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
310	Khurong Kewa Dara along Peling Dentam road, 15 km away from Geyzing, Tikjuk and lower Pelling, West Sikkim	23-06-2011	16 persons killed in multiple slides due to torrential rains b/n 8:30 pm and 11pm, collapsed the entire connectivity, power and water supply	http://sikkimnews.blogspot.com/2011/06/multiple-landslides-across-west-sikkim.html	H
311	Chamoli	30-06-2011	10 killed, Rishikesh-Badrinath closed	https://www.indiatvnews.com/news/india/5-000-tourists-trapped-near-uttarkashi-due-to-landslide-8805.html	H
312	Gangtok and its suburbs	30-06-2011	>100ft stretch of college boundary wall near the residential area collapsed and transmission lines snapped at Indira Byepass road	https://nidm.gov.in/PDF/pubs/bibliography%20landslide.pdf	M
313	Bhotaybhir, NH-31A, near Rangpo	05-07-2011	NH-31A cut off from the rest of country for 6 hours	https://www.hindustantimes.com/india/a-harrowing-night-s-tale-on-nh-31a/story-sH26SeR1vzTPv9fJ95u0CK.html	M
314	Kurseong, Darjeeling	17-06-2011	three children and a young father lost their lives to landslides in Kurseong (Darjeeling dist).	http://savethehills.blogspot.com/2011/06/one-day-of-rain-17jun2011.html	L
315	Tamenglong, Manipur	06-07-2011	6 killed 7 injured, NH-53 closed	https://www.ndtv.com/topic/landslide-in-manipur	H
316	Itanagar	19-07-2011	3 killed, NH-52A disrupted at many places	https://www.youtube.com/watch?v=9puUOXSJBig93.-Wwww9998	M
317	Pani nallah, Kishtwar distt, J&K	19-07-2011	3 killed	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	L
318	Likhu Bhir on NH-31A	20-07-2011	40m stretch of highway washed away	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	L
319	Chamoli	21-07-2011	1 killed 1 injured, bus damaged	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	L
320	Almora	21-07-2011	1 killed 4 injured, jeep damaged	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
321	20th mile Baghey khola, Singtham-Rangpo stretch	22-07-2011	NH-31 A blocked for 11 hours. Commuters spend night in vehicles	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	H
322	Daur Gaon, Narendranagar block, Tehri distt	11-09-2011	6 members of a family killed and 4 houses collapsed	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	M
323	Mangan, Chungthang, Lachung, JN road and NH-31A, Sikkim State	18-09-2011	>300 landslides occurred due to earthquake of M-6.9, causing house collapse, road blockade/ damages and loss of lives as well as injuries to people. Both fresh and reactivated landslides happened	RTFhttps://www.researchgate.net/publication/272905239_Historical_Records_of_Socio-economically_Significant_Landslides_in_Indial	H
324	Assam	26-06-2012	There is a report of sixteen people losing their lives in a landslide caused by heavy rain.The crucial rail link between Lumding and Badarpur, which is also the lifeline for Tripura, suffered extensive damage due to landslides at various locations	https://reliefweb.int/report/india/assam-floods-2012	H
325	Mizoram	21-08-2012	Rock fall at stone quarry, Keifang swept a bus down a ravine killing 19 and injured 16 persons	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
326	Aizawl-Tuirial road	08-08-2012	Landslide at Aizawl Tuirial road swept a Taxi down a cliff killing 3 and injured 3 persons	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	L
327	Ramhlun Sports Complex and Ramhlun Vengthar areas	11-08-2012	Subsidence started back in 2004 at Ramhlun Sports Complex and Ramhlun Vengthar areas, 7 houses were damaged and 56 families were evacuated	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
328	Okhimath area in the Uttarakhand	14-09-2012	As per news reports, this event resulted in the death of 51 people and a significant loss of property	https://link.springer.com/article/10.1007/s10346-013-0420-6	H
329	North Sikkim	23-09-2012	report that 21 people were killed in the Gangtok area alone. Most of these appear to have been the result of landslides on the road between Mangan and Chungthang, whilst a further eight people are missing in North Sikkim.	https://blogs.agu.org/landslideblog/2012/09/23/landslides-kill-27-people-in-sikkim-india/	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
330	Uttarakhand	16-06-2013	The entire State was hit by very heavy rainfall and flash floods. Though all the thirteen districts of the State were hit, five districts, namely Bageshwar, Chamoli, Pithoragarh, Rudraprayag and Uttar kashi were the worst affected. As per the report made available by the State Government on 09 May 2014, a total of 169 people died and 4021 people were reported missing (presumed to be dead).	https://nidm.gov.in/PDF/pubs/India%20Disaster%20Report%202013.pdf	H
331	Laipuitlang, Aizawl	11-05-2013	Destroyed 12 houses, killed 17 and injured 9 persons	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
332	Ramhlun Sports Complex and Ramhlun Vengthar areas	Jul-2013	Recurrence at Ramhlun Sports Complex and Ramhlun Vengthar areas, 15 houses damaged and a number of families evacuated.	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
333	Malin in the Ambegaon taluk of Pune district	30-08-2014	151 died	https://en.wikipedia.org/wiki/2014_Malin_landslide	H
334	Bhavnagar, HP Kinnaur	26-08-2014	2 died and 3 injured	https://timesofindia.indiatimes.com/india/village-in-himachals-kinnaur-faces-landslide-risk-govt-mulls-relocating-residents/articleshow/40080226.cms	L
335	Mawbah under Mayprem area in Meghalaya East Khasi Hills district	23-09-2014	8 died	https://zeenews.india.com/news/north-east/eight-die-of-landslide-in-east-khasi-hills_1474744.html	M
336	Banihal	26-02-2015	2 died and Two seriously injured and a vehicle totally damaged on the Jammu-Srinagar highway	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
337	Dabhol village of Ratanigiri	22-06-2015	12 people buried under the debris after three houses collapsed	https://www.dnaindia.com/india/report-ratnagiri-landslide-at-least-12-people-feared-buried-under-debris-2097800	H
338	Baltak road, Ladakh Highway	26-07-2015	Ladakh highway and the Baltak road for Amarnath pilgrims got washed away at many places leading to massive blockages after landslides triggered by cloudbursts.	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
339	Joumol village in Manipur's Chandel district	01-08-2015	20 people died in a landslide caused by heavy rain	https://www.ndtv.com/india-news/20-killed-in-manipur-landslide-rescue-teams-having-tough-time-reaching-site-1202958	H
340	Manikaran Saheb in Himachal Pradesh	18-08-2015	10 died	https://timesofindia.indiatimes.com/india/7-killed-in-landslide-in-manikaran-saheb-in-himachal-pradesh-many-feared-trapped/articleshow/48527243.cms	H
341	Banihal	22-09-2015	Jammu-Srinagar highway was closed for traffic for 3-4 days due to landslides triggered by heavy rainfall.	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
342	Batote-Doda National Highways	17-03-2016	5 died and Five injured due to landslides triggered by incessant rain	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
343	Tawang Town AP	18-05-2016	11 died and many houses get buried	https://www.gsi.gov.in/error_Pages/WLBridgeFailure.html	H
344	Tawang Town AP	22-04-2016 23-04-2016	18 died and severe damage to property, cattle.	https://www.ndtv.com/india-news/14-killed-in-landslide-in-arunachal-pradeshs-tawang-1398342	H
345	Ramban and Digdol	05-02-2017	Over 2,000 vehicles, including trucks loaded with essentials and tankers, were stranded on the highway due to the landslide	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
346	Ramban	20-02-2017	The Jammu-Srinagar highway was closed for traffic due to multiple landslides	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
347	Panthal, Ramban	13-03-2017	The Jammu-Srinagar highway was closed to traffic for over 3 days	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
348	Chamoli district	19-05-2017	Rishikesh-Badrinath national highway blocked for 2 days	https://www.indiatoday.in/india story/landslide-badrinath-route-uttarakhand-tourists - 978087-2017-05-19	M
349	Bali Nallah, Udhampur	21-05-2017	Over 200 vehicles were stranded at various places on the highway	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
350	Laptap village in Papum pare district	11-05-2017	14 died and 5 houses buried	https://arunachal24.in/arunachal-14-died-in-landslide-at-laptap-village-in-papum-pare-district/	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
351	South district of Sikkim	12-07-2017	6 dead and many injured and 5 houses damaged	https://www.oneindia.com/india/multiple-landslides-south-district-sikkim-claim-6-lives-2547714.html	M
352	Kotrupi landslide	13-08-2017	The nasty incident graved two buses of Himachal Road Transport Corporation and took forty six human lives. Several cattle beside wild fauna were also got buried, though their numbers were unknown. The few agriculture terraces/ fields, bikes and vegetable vehicles were also in the victims of landslides.	https://nidm.gov.in/PDF/pubs/Kotrupilandslide_2017.Pdf	H
353	Panthal-Batote-Doda-Kishtwar	13-08-2017	Fresh snowfall around Jawahar tunnel and landslides at Digdole and Panthal resulted in closure of the 294-km Srinagar-Jammu highway. About 30-40 vehicles were stranded at different places on the highway	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
354	Dhalli area Shimla	02-09-2017	No casualty, though road got blocked and a temple building was partially damaged.	https://timesofindia.indiatimes.com/city/chandigarh/massive-landslide-hits-national-highway-near-shimla-several-vehicles-buried/articleshow/60338106.cms	M
355	Namchi-Damthang Road South Sikkim	20-09-2017	six people were killed and two others injured	https://www.outlookindia.com/newsscroll/6-killed-as-landslides-hit-sikkim/1150700	M
356	Panthal stretch, Ramban	03-03-2018	2 died One car was badly damaged by the landslide. The Jammu-Srinagar highway was closed to traffic for almost a day due to landslide	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
357	Ladden Chadoora, Budgam	31-03-2018	16 died Traffic disrupted for over 10 days	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	H
358	Hnahthial, Kanan veng	11-06-2018	damaged NH 54, 250 metre (approx.)	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	M
359	Hunthar, Aizawl	12-06-2018	Recurrent Land subsidence 29 families evacuated during 2015-2019	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	M
360	Peddar Tehsil, Kishtwar	16-06-2018	3 died Five children injured. The landslide hit the shack on the road side causing death and injury of people living in it.	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
361	Doda-Kishtwar Highway	15-07-2018	7 died 12 person injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
362	Banihal	21-07-2018	Hundreds of vehicles, including a Jammu-bound convoy carrying Amarnath pilgrims, were stranded. Incident happened during heavy rains	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	M
363	Kulligad, Kishtwar	20-08-2018	1 person injured	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
364	Kishtwa	20-08-2018	Huge boulders and debris came down hitting mini-bus and a car (both vehicles damaged) plying on the Doda-Kishtwar road leading the casualty and injuring one person	http://jtfrp.in/wp-content/uploads/2019/01/JK_Data-inventory-Report_30Nov2018-RMSI.pdf	L
365	Itanagar	14-09-2018	three people died and as many others reported missing following flood and landslides in two areas of Arunachal Pradesh capital Itanagar	https://www.insidene.com/three-killed-missing-itanagar-landslides/	M
366	Gandoh (Doda) and Kathua	25-09-2018	5 and 2 died Respectively	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
367	Jammu-Srinagar National Highway (Ramban	09-10-2018	No casualty, though road got blocked	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
368	Banihal	20-10-2018	No casualty, though road got blocked	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
369	Jammu-Srinagar National Highway (Ramban	30-10-2018	1 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
370	Rajour& K	05-11-2018	3 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
371	Battery Chashma (Banihal Ramban)	15-11-2018	3 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
372	Gangroo (Ramsu)	15-12-2018	No casualty	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
373	Kharpur, Banihal	20-12-2018	No casualty	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
374	Maroog area (Ramban)	08-02-2019	2 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
375	PakalDul (Kishtwar)	23-02-2019	2 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
376	Khari Mahoo (Ramban)	17-03-2019	2 died and 3 injured	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
377	DharabShalaThathri (Doda)	24-04-2019	5 died and 9 injured	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
378	Loundna (Udhampur)	31-07-2019	1 died and 1 injured	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
379	Itanagar	17-06-2019	Two people injured and. According to officials, road communication in National Highway 415 interrupted.	https://arunachal24.in/arunachal-huge-landslide-in-itanagar-2-injured1-feared-trapped/	M
380	Aizawl to Champhai	19-06-2019	Road NH - 6 near Haidai river, totally damaged	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
381	College veng, Lunglei	July, 2019	12 families were evacuated and 7 residential houses are dismantled	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	M
382	Mizoram	19-07-2019 and 25-07-2019	Road (NH 54) blockade at Mualkhang area and Bawngkawn area respectively	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	M
383	Durtlang locality collapsed Mizoram	02-07-2019	3 Blocks of BSUP building at Durtlang locality collapsed due to landslide which claimed 3 lives and injuring 11 persons. 138 families wereevacuated	https://dmr.mizoram.gov.in/uploads/attachments/c5540f524215d78de7c680318d34f98b/mzsdmp-2020-combined.pdf	H
384	Dimapur Nagaland	26-10-2019	70 m boundary wall damaged 2 NIT's building damaged	https://www.gsi.gov.in/webcenter/portal/OCBIS/pageQuickLinks/pageLandslideIncidents19	H
385	Digdol (Ramban) & Nashri (Udhampur)	15-12-2019	2 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
386	Kabi North Sikkim	24-05-2020	A massive landslide hit Myong Kyong in Upper Dzongu in Sikkim killing two and leaving others injured washed away three houses in the area and partially damaged 11 other houses	https://www.insidene.com/sikkim-two-killed-in-landslide-several-houses-damaged/	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
387	Donyi colony	25-06-2020	A 2-year-old girl was killed	https://www.sentinelassam.com/north-east-india-news/arunachal-news/landslide-kills-2-year-old-minor-in-arunachals-donyi-colony-484884	L
388	Banihal (Ramban)	17-05-2020	2 died	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L
389	landslide that took place along NH-37	26-06-2020	Out of some 30 houses including Longmai-3, Church, houses belonging to Rongphun Rongmei, Hosea Riamei, from Longmai Part-3, Meisithuiyang Panmei and G Kinthuan, of Khumji-2 (Lukhambi) were affected the most.	http://e-pao.net/GP.asp?src=13..270720.jul20	L
390	Itanagr & Naharlagun	10-07-2020	seven people were killed and one person has gone missing after landslides struck houses in separate locations of the Itanagar capital region (ICR) Four persons, including an eight-month-old child, were buried alive in Tigdo village, near Yupia in Papum Pare district, when a landslide hit the residence of one Tana Neka.	https://arunachaltimes.in/index.php/2020/07/11/seven-killed-by-landslides-one-missing-in-itanagar-capital-region/	H
391	Kerela	06-08-2020	132+died and 82 injured several houses dmagaed.	https://en.wikipedia.org/wiki/2020_Kerala_floods	H
392	Tamil Nadu	06-08-2020	2 died & 2 injured. 5 houses damaged and agriculture land affected.	https://scroll.in/latest/969723/heavy-rain-triggers-landslides-flood-like-situation-in-tamil-nadu-karnataka	M
393	Pauri	24-08-2020	3 died	http://www.businessworld.in/article/Uttarakhand-Two-killed-1-feared-trapped-under-boulders-on-Rishikesh-Badrinath-Highway/24-08-2020-312233/	L
394	Khour Reasi	25-08-2020	4 died		L
395	Senapati Manipur	23-10-2020	cut off connectivity via the National Highway-2	http://www.businessworld.in/article/Manipur-Landslide in-Senapati-cut-off-connectivity-via-National-Highway-2/26-10-2020-335563/	M
396	Nagaland' dimpur	02-02-2021	three people were injured and four vehicles damaged in a major rockslide incident in Nagaland's Dimapur district	https://www.indiatoday.in/india/story/three-injured-several-vehicles-damaged-in-rockslide-in-nagaland-dimapur-1765274-2021-02-02	L
397	Chamoli district	07-02-2021	80 persons died and 124 went misisng	https://www.youtube.com watch?v=f E6yjZE6pUg	H
398	Samroli (Udhampur)	26-03-2021	1 died 2 injured	http://www.questjournals.org/jrees/papers/vol7-issue5/G07055254.pdf	L

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
399	Dharmshala & Palam pur	12-07-2021	As per the reports, about 12 people were missing in remote Boh valley as a massive landslide dumped thousands of tons of debris over their houses.	https://www.tribuneindia.com/news/himachal/himachal-massive-landslide-dumps-five-houses-under-thousands-tons-of-debris-in-boh-valley-in-kangra-district-282071	H
400	Boh village	12-07-2021	resulting in loss of ten lives and washing away of seven major houses, other constructions, road and agricultural land. The incidence also made the adjoining areas unstable.	https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=3475	H
401	2021 Mumbai landslide	18-07-2021	32 died and 5 injured	https://en.wikipedia.org/wiki/2021_Mumbai_landslide	H
402	Sangla-Chitkul road, district Kinnaur	25-07-2021	The incidence resulted in boulder hit smashing of a mini bus along with death of nine tourists and casualty of three others, including a local	https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=3476	H
			resident. The massive rock fall was reported to have continued for nearly another one and half minutes also resulted in severe damage to Sangla Chitkul and Sangla-Batseri link roads, collapse of the Batseri Bailey bridge on Baspa River, a public facility construction and stumping of several mature trees along the trajectory		
403	Kali Dhank near Barwas village	30-07-2021	The landslide took away a major portion of hill mass resulting in complete washout of 150m road stretch of NH 707 without any casualty or any other property damage.	https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=3477	H
404	Chamba	04-08-2021	No casualties have been witnessed in this incident. The place where the disaster of breaking the mountain occurred is the Bharmour-Hadsar road of Chamba district.	https://www.aajtak.in/india/himachal-pradesh/video/chamba-video-himachal-pradesh-landslide-mountain-cracked-and-fell-on-roads-1303606-2021-08-04	L
405	Nigulsari Village, Tehsil Nichar, District Kinnaur	11-08-2021	As per media reports, the slide debris engulfed one HRTC Bus with reportedly 30 passengers onboard. Moreover, at least 4-5 smaller four wheelers and a few cattle have also been engulfed in debris causing loss to life and property. Furthermore, damage to highway and valley side metallic girders/railing have also been caused by the above incidence. As on the day of field observation,	https://hpsdma.nic.in//admnis/admin/showimg.aspx?ID=3473	H

Sl. No.	Location	Year	Impact	Source	Socio-economic Class
			23 dead bodies were recovered, as intimated by the Gram Pradhan, Trianda		
406	Garola on Chamba-Holi road	24-08-2021	brought traffic movement to a standstill around 2 am Travellers were forced to spend around 12 hours in their vehicles until the affected section was cleared. Another landslide was reported around 5 am when boulders slid on to the Kalka-Shimla NH5 near Dharampur. The suddenness of the landslide triggered panic braking, which led to a tailup.	https://www.newindianexpress.com/nation/2021/aug/24/no-casualty-reported-in-two-landslides-in-himachal-traffic-movement-affected-2348912.html	H
407	Lahaul landslide	25-08-2021	One person was killed, while another was injured at Kaurik village in tribal district Lahaul Spiti	https://www.tribuneindia.com/news/himachal/labourer-killed-in-lahaul-landslide-302084	L
408	Sukki Top Bhatwari area	14-09-2021	the Gangotri highway was blocked after landslide at Sukki Top area of Bhatwari block.Similarly, Yamunotri highway was also blocked due to landslide.	https://timesofindia.india times.com/city/dehradun/landslides-block-gangotri-and-yamunotri-highways-for-hours/articleshow/86191265.cms	M
409	Shimla building collapse	30-09-2021	a multistoreyd building which in turn damaged 2 adajacent structures.	https://www.tribuneindia.com/news/himachal/shimla-building-collapse-no-steps-taken-to-enforce-guidelines-321307	H
410	Landslides in Uttarakhand	17-10-2021 19-10-2021	As per an official statement released by the Uttarakhand administration, 79 deaths were reported in the state from October 17 to October 19 as a result of natural disasters caused by heavy rainfall in the state. Nainital recorded the highest number of deaths, with 35, followed by Champawat with 11. The rain also caused widespread devastation in the form of landslides, house collapses and deluges, resulting in the deaths and destruction of property across the state. In those three days, a total of 232 homes were damaged.	https://www.republicworld.com/india-news/accidents-and-disasters/uttarakhand-govt-data-shows-79-lost-their-lives-due-to-natural-disasters-from-oct-17-19.html	H
411	Dadam mining zone in Tosham block of Haryana's Bhiwani district	01-01-2022	four mining workers were killed and several others feared trapped under the debris following a landslide	https://indianexpress.com/article/cities/chandigarh/haryana-mine-landlide-accident-live-updates-7701050/	M
412	Haryana's Kangarka village	10-01-2022	four girls were buried to death in a landslide	https://www.indiatoday in/india/story/haryana-village-girls-death-landslide-kangarka- 1898465-2022-01-11	M

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https://keralakaumudi.com/en/news/news.php?id=616173&u=kinnaur-landslide-pm-condoles-deaths-announces-Rs-2-lakh-ex-gratia-for-kin-of-those-killed-616173

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c) Kerala Landslide
https://www.mtu.edu/news/2021/03/geological-engineers-create-landslide-atlas-of-kerala-india.html

d) Landslip in Shimla on August 18th, 2019, Photo Courtesy PTI https://www.thehindu.com/news/national/18-killed-in-rain-related-incidents-in-himachal-pradesh/article29126341.ece.

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