GETTING A GRIP ON LANDSLIDES

REDUCING THE RISK OF LANDSLIDES IN INDIA

REFORMS THAT TRANSFORMED

NATIONAL DISASTER MANAGEMENT AUTHORITY

MINISTRY OF HOME AFFAIRS, GOVERNMENT OF INDIA

REDUCING THE RISK OF LANDSLIDES IN INDIA

Introduction

India a landslide-prone country

India is a country prone to different types of landslides. This calamity can cause significant destruction in terms of loss of lives and property. As per the Geological Survey of India (GSI), about 0.42 million km2 (covering nearly 12.6% of the land area of our country) is prone to landslides (Figure 1). The mountainous region of the north-western Himalayas (Jammu & Kashmir, Himachal Pradesh, Uttarakhand), the sub-Himalayan terrain of the north-east (Sikkim, West Bengal-Darjeeling, Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Tripura), the Western Ghat areas (Maharashtra, Goa, Karnataka, Kerala) and the Eastern Ghat areas (Araku area of Andhra Pradesh, Tamil Nadu) are prone to landslides.

Landslides are a threat to life and property. They seriously impair the livelihoods of citizens as they disrupt normal economic activities in the hilly regions of India. Landslides and land-mass movements occur not only in the largely mountainous states of Himachal Pradesh, Uttarakhand, Jammu & Kashmir and the states of the north-east, but also in the hilly areas of states like Maharashtra, Karnataka and Kerala.

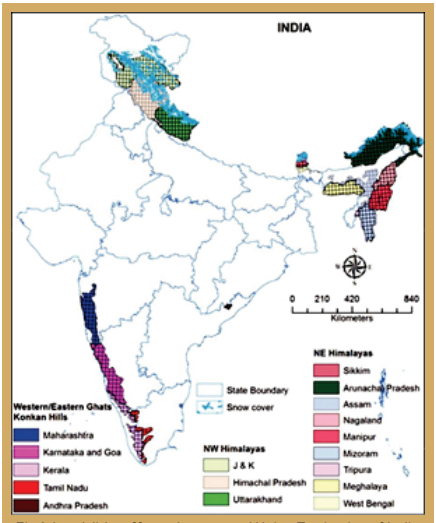

Fig 1: Landslide-affected states and Union Territories of India (Source: GSI)

> Technology and resources would go a long way in maximizing our collective impact and would enhance the efficiency of our disaster risk management efforts.
>
> - **Shri Narendra Modi**, Prime Minister
> AMCDRR, 2016

Landslides occur frequently in the Himalayan and other landslide-prone hilly areas in the country especially during the monsoon as a result of heavy rainfall. The majority of the landslide-prone areas in India happen to be located in regions that are also earthquake prone. Thus, these areas are susceptible to earthquake-triggered landslides, which happened, for example, during the Sikkim (2011), Kashmir (2005), Chamoli (1999) and Uttarkashi (1991) earthquakes.

Landslide incidence has increased - a major challenge for technocrats

It is estimated that economic loss due to landslides may amount to much as 1% to 2% of the Gross National Product in many developing countries. In fact, 80% of the reported fatalities due to landslides occur in developing countries. Therefore, evaluation and mitigation of this hazard and risk is a major challenge for the technocrats and decision makers in the developing world

In recent years, the incidence of landslides has increased due to extreme weather events, environmental degradation due to human interference and other anthropogenic activities, resulting in heavy loss of human lives, livestock and property. Therefore, it is a growing

challenge before the technocrats of the country to minimize these losses. This is also an opportunity for them to create technology solutions through application of artificial intelligence to minimize the impacts of landslides in the future. Since local communities are the first responders in any disaster, the technological solutions should be tailored keeping in mind their needs and requirements.

Background

Guidelines from NDMA

In June 2009, the National Disaster Management Authority released the Guidelines on Management of Landslides and Snow Avalanches, laying down national policy for the management of landslides and related activities in the country. The guidelines were formulated in consultation with the Ministry of Mines, Geological Survey of India and other concerned Central and state departments, as well as academia (Figure 2).

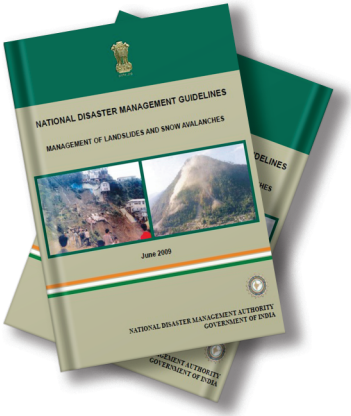

Fig 2: NDMA Guidelines on Management of Landslides & Snow Avalanches

Even though the guidelines were issued in 2009, progress by way of their implementation was limited in the landslide-affected states/UTs.

"We express our sincere thanks to the Government of India for initiating reconstruction work at Hunthar landslide area, which has caused immense troubles to the people in the locality in particular and also to the people of Aizawl in general for over twenty years. We hope that this project, once completed, will greatly benefit the people living in the area."

- Lalhmangaiha Renthlei
Chairman, Hunthar Local Council

"I am thankful to NDMA for taking up the Landslide Risk Mitigation Scheme (LRMS) at Hunthar locality. The landslide at Hunthar has destroyed several houses and many families have been displaced and relocated elsewhere. This project, once it is completed, will stop further landslides and prevent soil movement, thereby bringing back confidence among the people in the locality and reviving their economic activities."

- R. Lalramnghaka,
Deputy Commissioner & Chairman
Aizawl District Disaster Management Authority, Aizawl

Initiatives

The Landslide Risk Mitigation Scheme

The most important requirement for landslide mitigation was the participation of the state governments and other stakeholder agencies. On 19 December 2014, NDMA conducted a state-level meeting with landslide-prone states/UTs and concerned departments and institutes to discuss the 'Landslide Risk Mitigation Scheme' (LRMS) and other landslide-related issues. Representatives from fourteen states and nine departments participated in the meeting. It was noted during the meeting that before 2014, NDMA had had several correspondences with the states to identify vulnerable sites and develop projects to mitigate the effects of possible landslides in the future, but they had not resulted in any action. Detailed deliberations were held on the draft template for the preparation of detailed project reports (DPRs) for site-specific landslide risk mitigation. Representatives of the states which participated in the meeting unanimously agreed to submit their DPRs and support the LRMS project of NDMA.

Based on this consultation, NDMA released a template for preparation of DPRs for site-specific landslide risk mitigation in June 2015 (Figure 3) and circulated it to all the landslide-affected states and union territories. Landslide-risk mitigation was highlighted in the National Disaster Management Plan of 2016, which was updated in 2019. The importance of preparing their individual, holistic disaster management plans was impressed upon all State/UT governments and other agencies.

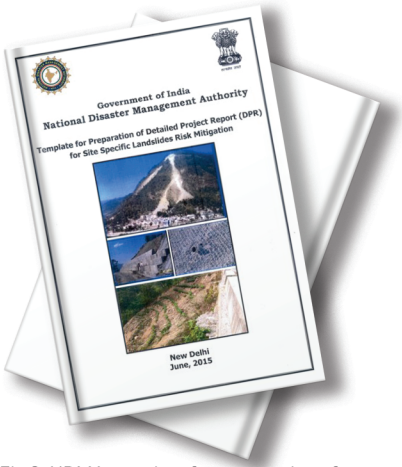

Fig 3: NDMA template for preparation of DPR on landslide-risk mitigation.

Fig 4: Landslide treatment works carried out under LRMS

In July 2019, NDMA launched the LRMS to provide financial and technical support to landslide-prone states for site-specific landslide mitigation. The LRMS is a pilot scheme to demonstrate the benefits of landslide treatment measures by application of different methods of slope stabilization, along with landslide monitoring, awareness generation and capacity building/training, etc.

Memorandum of understanding (MOU) was signed with the state disaster management authorities (SDMAs) of Sikkim, Mizoram, Nagaland and Uttarakhand for implementation of the schemes and landslide treatment works that were in progress at the sites of Mangan (Sikkim), Hunthar Veng (Mizoram), Kohima-Thizama road (Nagaland), Kempty-Chadogi road and Hardiyanala-Karnprayag road (Uttarakhand).

"We were introduced to formats for DPR preparation and projects done in other parts of the country. It has given us the confidence to initiate projects locally using techniques introduced to us during the training and to implement LRMS projects locally and elsewhere."

- Pemzang Tenzing,
Project Coordinator Mangan Landslide
Mitigation Project SSDMA, Mangan Sikkim

Training programmes on Landslide Mitigation and DPR preparation

During the conceptualization and formulation of the LRMS, it was seen that state governments and departments of the Central government had many difficulties in preparing their DPRs on landslide mitigation, in stabilizing slopes, and in making other landslide studies.

To increase their awareness of the subject and help the concerned departments in the States/UTs and other stakeholders in capacity building, NDMA initiated a project in June 2018, consisting of 5-day and 2-day professional training sessions on 'Landslide Mitigation and DPR Preparation' for them. This was done in collaboration with expert institutions like the IITs, Indian Institute of Science (IISc), North Eastern Hill University (NEHU)-Shillong, Central Building Research Institute (CBRI), Central Road Research Institute (CRRI) and National Institute of Technology (NIT)-Mizoram.

Fig 5 : Training programme on landslide mitigation and DPR preparation

Until date, six 5-day and six 2-day training programmes have been conducted at institutions across the country, such as the CRRI-New Delhi, CBRI-Roorkee, NIDM-New Delhi, IIT-Mandi (Himachal Pradesh), IISc-Bangalore, NEHU-Shillong, NIT-Mizoram and IIT-Roorkee. In all, 316 participants from different states and UTs, Central government departments and other institutions received training in landslide mitigation and DPR preparation. Currently, due to the COVID-19 pandemic, training programmes are being conducted through online platforms.

Development of low-cost landslide monitoring and EWS

The difficulties in preventing landslides are further compounded by the fact that existing landslide monitoring and early warning technologies cost crores of rupees, and that these technologies may not be capable of generating advisories for weather and slope movements ahead of time. The Himalayas and other mountain regions of India are vast and varying in nature, and the need for a low-cost landslide early warning system (EWS) has been long recognized.

In December 2017, NDMA launched a pilot project, 'Development & Evaluation of Low-Cost Landslide Monitoring Solutions', in collaboration with IIT Mandi and Defence Terrain Research Laboratory

"The training helped me understand the requirements and actual outcomes from the project. Being a project coordinator for LRMS, Uttarakhand, the programme helped us focus more on capacity building among the stakeholders, students, etc."

- Kumar Kanishk,
Project Coordinator
WD, USDMA Uttarakhand

> “The 5-day online training programme was informative, relevant and very helpful. It is definitely going to help us tailor our DPR in a more informed way (geologically, and with an understanding of geomorphological aspects and basic structural engineering). Looking forward to more such trainings and site visits.”
>
> **- Keshav Koirala,**
> Training Officer Sikkim State Disaster Management Authority Government of Sikkim

(DTRL)-DRDO. The project aimed to develop low-cost sensors and other instruments for landslide monitoring, using micro electro mechanical systems(MEMS)-based sensor technology and artificial intelligence. After detailed studies and experimentation, the project successfully developed a low-cost landslide monitoring, warning and prediction system.

Innovations & Artificial Intelligence

The system developed under this project addresses some of the issues in the existing technologies, such as their high cost and their lack of predictive capacity (Figures 6 & 7). The new system detects whether there is significant soil movement and activates roadside blinkers and hooters wirelessly so that vehicular road traffic can be alerted. The blinkers and hooters come on for 10-15 seconds with lights and sound each time soil movement is recorded at the deployment site.

In addition, the system also sends SMS messages about soil movements to disaster managers and the local people on their mobile phones. Recently, the system was been able to generate predictive messages about impending soil movements one day ahead of time as well as issue severe-weather advisories two hours ahead of severe weather events. The predictions of soil movements and severe weather are triggered by artificial intelligence (AI) algorithms running on a cloud-based server.

Fig 6: Low-cost landslide-monitoring and early warning system (EWS).

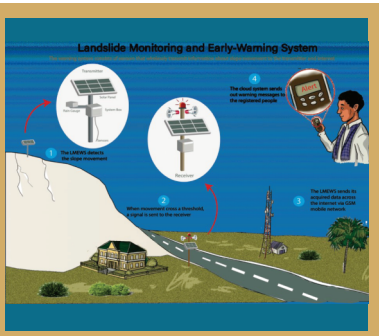

Fig 7: Diagram showing how the low-cost landslide-monitoring, warning and prediction system operates

The developed system predicts the amount and magnitude of soil movement. While the information as to the number of landslides is useful for research, the information about their magnitude is most helpful in generating alerts for different stakeholders ahead of an event. The predictive algorithms are currently being refined, and the team from IIT Mandi is testing the system. Due to its low cost and predictive abilities, the system provides immense possibilities for deployment at a number of landslide sites in India.

"The Landslide Risk Mitigation Scheme (LRMS) provides us a platiorm with direct access to expertise and funds for addressing landslides that plague our district. LRMS has funded the Mitigation of Landslide at Mangan project and many rechniques that are novel to Sikkim in tackling landslides and envisaged in this project. We are sure that the project, once implemented, will address our site specific problem and can be replicated at other sites."

- Sonam Lepcha
Additional District Collector,
North District, Mangan

Fig 8: Sub-surface landslide monitoring system installed at Gharpa hill, Himachal Pradesh

The earlier systems had been developed for monitoring surface-based movements, but recently the system has also been perfected for detecting sub-surface movements. For this purpose, boreholes are made at the landslide site and a chain of multiple sensor nodes inserted into them for recording sub-surface movements. Each sensor node measures accelerations and displacements via an accelerometer, soil moisture via a capacitive soil moisture sensor, and soil stress via a piezoelectric pressure sensor. The data collected from the system is sent to the cloud server via GSM mobile technology. Also, the patented system runs autonomously on solar power and does not depend on grid power. The system's electronics have been optimized to consume very low amounts of energy, where the battery can help sustain the system for days when there is no sunlight.

Collaboration with local administrations

With the support of NDMA, DTRL-DRDO and the Mandi district administration, more than ten systems have been deployed by IIT Mandi in Mandi district at different landslide sites along the Mandi-Jogindarnagar and Mandi-Kullu highways. Each system can monitor soil movement and weather parameters at the deployed locations.

These parameters can be monitored online on a dedicated website. Besides, the system has the capability of intimating the populations in the area about significant rainfall and slope-movement events in their vicinity via SMS service.

Landslide Strategy and Public Awareness Generation

The National Landslide Risk Management Strategy was released on 27 September, 2019 at the 15th Formation Day of NDMA. This strategy document addresses all the components of landslide disaster risk reduction and management, such as hazard mapping, monitoring and early warning systems, awareness programmes, capacity building and training, regulations and policies, stabilization and mitigation of landslides, etc.

The document envisages specific recommendations for the concerned nodal agencies, ministries, departments, states, civil society organizations (CSOs) and other stakeholders, to avert or reduce the impact of future landslide calamities.

NDMA is building awareness about landslides through print and electronic media, through a weekly panel discussion ('Aapda Ka Saamna') and telecast of a programme on 'Landslide Hazard & its Prevention' on Doordarshan channel. Additionally, a webinar on 'Landslide Risk Reduction through Community Participation' was conducted on 29 October 2020.

Outcomes of NDMA Initiatives

Landslide Risk Mitigation Scheme (LRMS)

The LRMS scheme will benefit landslide-prone states and union territories by helping them prevent future landslides by taking proactive initiatives through the lessons learnt under the scheme.

Training programmes on Landslide Mitigation and DPR preparation

The training programme has been greatly beneficial to the landslide-affected states/UTs, with the master trainers turned out by the programme assisting them in the preparation of DPRs for landslide treatment and in building the capacities of other stakeholders in their respective States/UTs. The DPRs received from the concerned States/UTs will be executed and implemented through LRMS.

Development of low-cost landslide monitoring and EWS

Calibration and validation of data obtained at different landslides sites are in progress to generate a reliable early warning model to save precious lives. This low-cost landslide monitoring technology will be beneficial in saving lives and property in the future by providing early warning alerts to the community members and local administration. The outcomes of this project will be shared with all landslide-affected states for replication of the low-cost landslide monitoring system and generation of early warnings in a cost-effective manner in collaboration with their own local communities and authorities.

"The Landslide Risk Mitigation Scheme at Thizama -Kohima road has tremendously helped the people of the vicinity. It has reduced the stress of traffic as well as for the pedestrians. People have witnessed new method of antilandslide and slope protection from this project."

- Keneizhatuo Kuotsu
Local Commuter, Kohima Village

“India's motto is
'Reform, Perform, Transform'.”

Prime Minister **Shri Narendra Modi**