



Landslide hazard scenario & landslide forecasting in India

Geological Survey of India

Landslide Hazard Scenario in India

India is one of the most physiographically rich and complex terrains in the world having the mighty Himalayan Mountains in the North, the vast coastal tracts all along the southwest, south, and southeast boundaries, fertile alluvial plains in the middle, and plateaus, and deserts in the west. Amidst the above geomorphic variety, India also has a varied and complex geological milieu consisting of the deformed and tectonically active Himalayan Belt in the north and the Arakan-Yoma belt in the east; relative inactive but geologically complex hilly and mountainous peninsular terrain, deformed/ un-deformed sedimentary rocks of several peninsular basins from the oldest Precambrian age to the recent; the Deccan plateau volcanic province, etc.

Amidst the above inherent physiographic and geologically variable terrains, the threat from various natural geohazards is quite high. Amongst them, the landslide hazard is one of the most menacing hazards faced by our country every year mostly during monsoon, causing perennial losses to precious lives and properties, where the Ministry of Mines and Geological Survey of India are continuously engaged in providing the relevant geoscientific inputs as the nodal ministry/ agency to all the stakeholders.

In India, **4.2 lakh km²** areas of hilly/ mountainous terrains in parts of **19** States/ UTs are vulnerable to varied types of landslide hazards, which affect parts of **179** districts. GSI has already prepared the baseline landslide susceptibility maps for the entire landslide-prone areas on 1:50,000 scale, and inventoried **87,474** nos. of active landslides (Table 1). With the above baseline data, the country is poised to act fast in generating and providing relevant additional geoinformation on larger scales too for the selected critical areas to the local administrators to act in a timely manner for the right mitigation of this hazard and also to develop and implement an easy-to-use, effective, and appropriate landslide early warning system (LEWS) to reduce losses of precious lives. The above baseline landslide susceptibility and inventory data are already uploaded in GSI's Bhukosh Map Portal (<https://bhukosh.gsi.gov.in/Bhukosh/Public>) for free downloading by all.

Table 1: Landslide Hazard Scenario in India

State/ UT	Target area (sq.km.)	High Susc %	LS Number	LS Number Density
UT: J&K	28890	11	7470	0.26
UT: Ladakh	40065	21	833	0.02
Himachal Pradesh	42093	26	17102	0.41
Uttarakhand	39009	22	14780	0.38
Sikkim	4979	18	3378	0.68
West Bengal	2980	17	1553	0.52
Assam	24144	2	527	0.02
Meghalaya	22601	1	1525	0.07
Manipur	23245	12	2404	0.10
Nagaland	17294	16	2740	0.16
Mizoram	21865	16	4219	0.19
Tripura	1367	2	57	0.04
Arunachal Pradesh	70308	15	26213	0.37
Maharashtra	29191	4	1139	0.04
Kerala	19301	13	1395	0.07
Karnataka	31323	4	1252	0.04
Goa	3546	5	76	0.02
Tamil Nadu	10549	6	782	0.07
Andhra Pradesh	1114	6	29	0.03
Total	433863		87474	0.20
LS = Landslide				

Landslide Early Warning System (LEWS)

The Ministry of Mines/ GSI has taken recently a bold stride in developing and operationalising regional LEWS for the country, and to implement that, a new state-of-the-art landslide forecasting facility – the **National Landslide Forecasting Centre (NLFC)** has been created by GSI, which has been inaugurated by the Hon'ble Union Minister of Mines on **19.07.2024** with a collective commitment from the Ministry of Mines and GSI to serve the best in the future for the landslide early warning in the country. With the inauguration of NLFC, GSI has started issuing landslide forecast bulletins of Darjeeling, Kalimpong districts of West Bengal, and the Nilgiris of Tamil Nadu in an operational mode using its dedicated landslide web portal (<https://bhusanket.gsi.gov.in/>), after extensive ground testing in those areas since 2020. Apart from the above operational landslide forecast bulletins, GSI is also issuing daily the landslide forecast bulletins on experimental model to 13 other districts in Sikkim, Uttarakhand, Himachal Pradesh, and Kerala to the concerned SDMA's and DDMA's only for feedback and ground testing. GSI currently is working on several districts, and soon will add more areas in its regional LEWS endeavour as per a perspective plan (**Fig. 1**).

Landslide is a complex phenomenon, and with the growing development and urbanization in the fragile hilly/ mountainous terrains, predicting landslide occurrences correctly always in space and time may not be a trivial job. It needs to



be implemented on the ground for long-term testing, modified based on feedback and fine-tuned further with time. With operationalization of NLFC, coupled with GSI's 173-year-long rich experience in geoscience and topography, MoM/ GSI will endeavour for the best and will further enhance the required skills, and capacities manifold in the future to give relevant, accurate, and timely landslide forecasting in the country.

State/ UT (No. of Districts)	District Name (s)	Year of Initiation	R&D Phase	Experimental Bulletin & Ground Testing	Operational bulletins in 2024 for wider testing
Sikkim (06)	Soreng, Pakyong, Mangan, Gyalshing, Gangtok, Namchi	2021			
Assam (02)	Dima Hasao, Cachar	2022			
Meghalaya (03)	Ri-Bhoi, Jaintia, Khasi Hills				
Mizoram (02)	Kolasib, Aizawl				
Nagaland (03)	Para, Kohima, Dimapur				
Karnataka (02)	Kodagu, Dakshin Kanara				
Kerala (13)	Wayanad	2021			
	Other 12 districts	2022			
Tamil Nadu (03)	The Nilgiris	2018			
	Coimbatore, Dindigul	2023			
Uttarakhand (03)	Rudrapur	2020			
	Chamoli, Uttarkashi, Tehri Garhwal	2022			
	Dehradun, Nainital, Pauri Garhwal	2023			
	Pithoragarh, Almora, Bageswar				
Himachal Pradesh (02)	Shimla, Kinnaur	2022			
West Bengal (02)	Darjeeling	2018			
	Kalimpong	2021			
UT: J&K (02)	Doda, Ramban	2024			
Maharashtra (03)	Pune, Raigarh, Ratnagiri	2025			
Arunachal Pradesh (05)	Longding, East Kameng, Changlang, Papum Pare, East Siang	2025			

Fig. 1: Current Status and Future Plans of GSI's regional LEWS endeavour

However, a rich background in R&D has already been there in this endeavour by GSI since 2017, when through the implementation of a multi-consortium-based international research program – LANDSLIP, a prototype landslide forecasting model was developed, which GSI had started ground testing in 2020 at two locations (Darjeeling district, West Bengal, and the Nilgiris, Tamil Nadu), and later up-scaled similar experimentation with terrain-specific modifications to 14 landslide-prone districts in Sikkim, West Bengal, Uttarakhand, Himachal Pradesh, and Kerala till date. The ultimate aim is to implement regional landslide forecasting in an operational mode in all the 19 landslide-prone States/ Uts in a phased manner so that soon the country is equipped with a robust system of regional landslide early warning for all the vulnerable locations.

In the above endeavour of regional LEWS, GSI is using the input data from India Meteorological Department (IMD), National Centre for Medium Range Weather Forecasting (NCMRWF) of Ministry of Earth Sciences, National Remote Sensing Centre (NRSC) of Department of Space, National Disaster Management Authority (NDMA),



and all the concerned State Disaster Management Authorities (SDMAs), District Disaster Management Authorities (DDMAs for developing a robust landslide early warning system for the country.

Apart from regional LEWS, there are a few institutions, like Amrita Viswa Vidyapeetham, Kerala, IIT-Mandi, CSIR-CBRI, DGRE, etc. who have also installed a few state-of-the-art ground-based site-specific/ slope-specific landslide early warning systems in Munnar, Kerala, Chandmari landslide, Gangtok, Sikkim, in some locations in Mandi district, Himachal Pradesh, etc. Such ground-based slope-specific LEWS installations may be required more in numbers in the country for such super-critical and vulnerable hill towns, road sectors, etc. implemented by multiple stakeholders. However, slope-specific LEWS using ground-based installations is also a humongous and costly task given the large number of active landslides present in the country (>80,000 in numbers).
