Need of National Landslide Risk Management Strategy for Reducing Landslide Risk in India

Ravinder Singh* and Surya Parkash**

Abstract

National Disaster Management Authority (NDMA), is the apex body for the disaster management in India under the Chairmanship of the Hon'ble Prime Minister, is mandated to lay down the policies, plans and guidelines for disaster management to ensure a timely and effective response to disasters. India is vulnerable to different landslides which cause significant destruction in terms of loss of lives and property. As per GSI, about 0.42 million km^2 covering nearly 12.6 per cent of the land area of our country is prone to landslide hazards. At present, no Ministry/Department of the Government of India (GoI)has formulated a national level landslide risk management strategy. In order to fill in this gap, NDMA formulated National Landslide Risk Management Strategy to adopt a holistic approach for mainstreaming landslide risk reduction, besides strengthening of the State machinery and providing all necessary technical support to the concerned States and Union Territories (UT's) for addressing landslide problem in a sustained manner. In this regard, NDMA had constituted a Task Force of experts from diverse backgrounds for the formulation of a national and local level strategy for landslide risk reduction. The strategy is fulfilling the fifth target of Sendai Framework for Disaster Risk Reduction (2015-30) i.e., Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020. The strategy document was released in the 15th Formation Day of NDMA on 27 September 2019; addresses all the components of landslide disaster risk reduction and management such as hazard mapping, monitoring and early warning system, awareness programmes, capacity building and training, regulations and policies, stabilisation and mitigation of landslide, etc. The strategy document envisages specific recommendations for the concerned Nodal Agency, Ministries/Departments, States and other stakeholders, so as to avert or reduce the impact of future landslide calamities.

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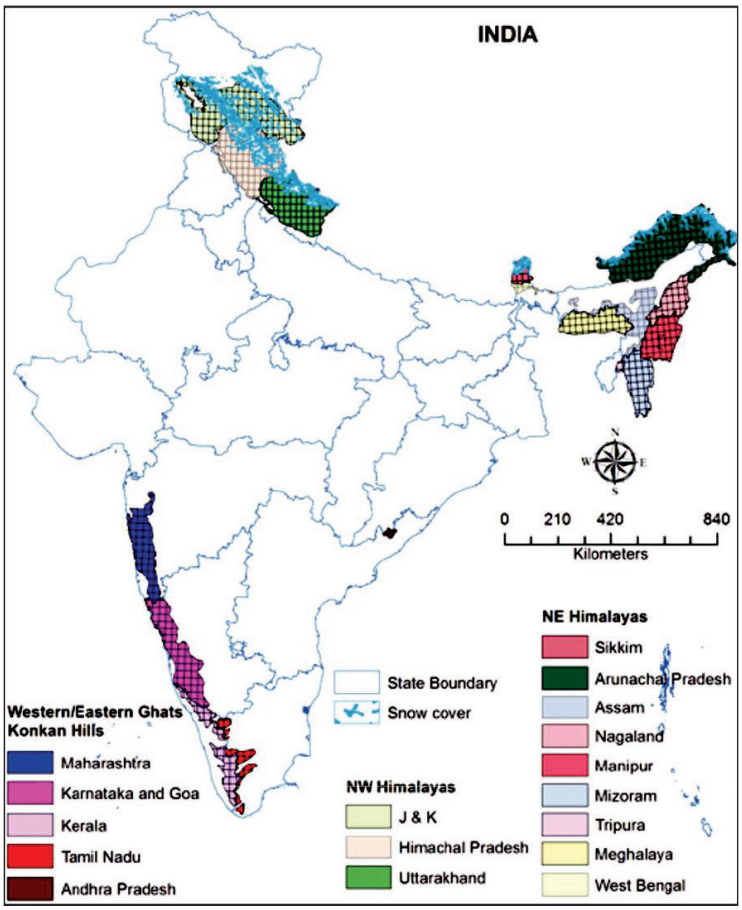
Introduction

India is vulnerable to different types of landslides which cause significant destruction in terms of loss of lives and property. As per GSI, about 0.42 million km^2 covering nearly 12.6 per cent of land area of our country is prone to landslide hazards (Fig. 4.1). The mountainous region of the North-Western Himalayas, the Sub-Himalayan terrain of the North-East, the Western and Eastern Ghats are prone to landslides.

Fig. 4.1: Major landslide prone areas of India (0.42 million km^2)



Landslide hazards rank high among the hydro-geological hazards because they pose a threat to life and livelihood ranging from disruptions of normal activities to widespread loss of life, property and destruction in large parts of the mountainous region of India. Himalayan and other hilly regions of India are affected by landslides and landmass movement activities. During the monsoon, these areas witness frequent landslides. Some of the major recent incidents are Kerala (2018), Himachal Pradesh (2018), Uttarakhand (2018), Tamenglong-Manipur (2018), Kalikhola, Manipur (June 2017); Laptap, Pampare-Arunachal Pradesh (July 2017); Malpa, Uttarakhand (August 2017); Kotropi, Himachal Pradesh (August 2017); Malin, Pune (July 2014); Mirik, West Bengal (June 2015), etc. causing huge loss to life and property. Most of the landslides occur due to heavy rainfall. Majority of landslide-prone areas are located in the earthquake-prone seismic Zone-IV and V. Thus these areas are also prone to earthquake-triggered landslides e.g., Sikkim Earthquake (2011), Kashmir Earthquake (2005), Chamoli Earthquake (1999), Uttarkashi Earthquake (1991), etc. In recent years, the incidences of landslides have increased due to extreme weather events, environmental degradation due to human interference and other anthropogenic activities resulting in heavy losses of human lives, livestock and property.

As per the Disaster Management Act, 2005 the National Disaster Management Authority (NDMA), a statutory and apex body under the Chairmanship of the Prime Minister, is mandated to lay down the policies, plans and guidelines for disaster management to ensure a timely and effective response to disasters. In June 2009, NDMA released the National Disaster Management Guidelines on Management of Landslides and Snow Avalanches formulated in consultation with the Nodal Ministry/Agency (MoM/GSI) and other core group members from concerned Central, State departments and academia, laying down national policy for the management of landslide related hazards in the country.

NDMA constituted a Task Force of experts for the formulation of National Landslide Risk Management Strategy. Task Force comprising of experts from diverse backgrounds in the relevant fields to identify problem/gaps, reviews of past work, recommendations, implementation strategy, financial implications, monitoring mechanisms etc. was constituted to formulate the strategy. The Task Force was divided into six Sub-Groups as under:

- Generation of User-FriendlyLandslide Hazard Map
- Development of LandslideMonitoring and Early Warning System
- Awareness Programmes
- Capacity Building and Training of stakeholders
- Preparation of Mountain ZoneRegulations & Policies

- Stabilization and Mitigation of landslides and Creation of Special Purpose Vehicle (SPV) for Landslide Management

Discussion

The strategy clearly brings out the message for the need to strengthen and mainstream landslide disaster preparedness, mitigation, response and relief mechanism through mapping, early warning system (EWS), awareness generation, capacity building, formulation of mountain zone regulations/policies and mitigation of problematic landslides. The important points of six sub-groups are highlighted as follow:

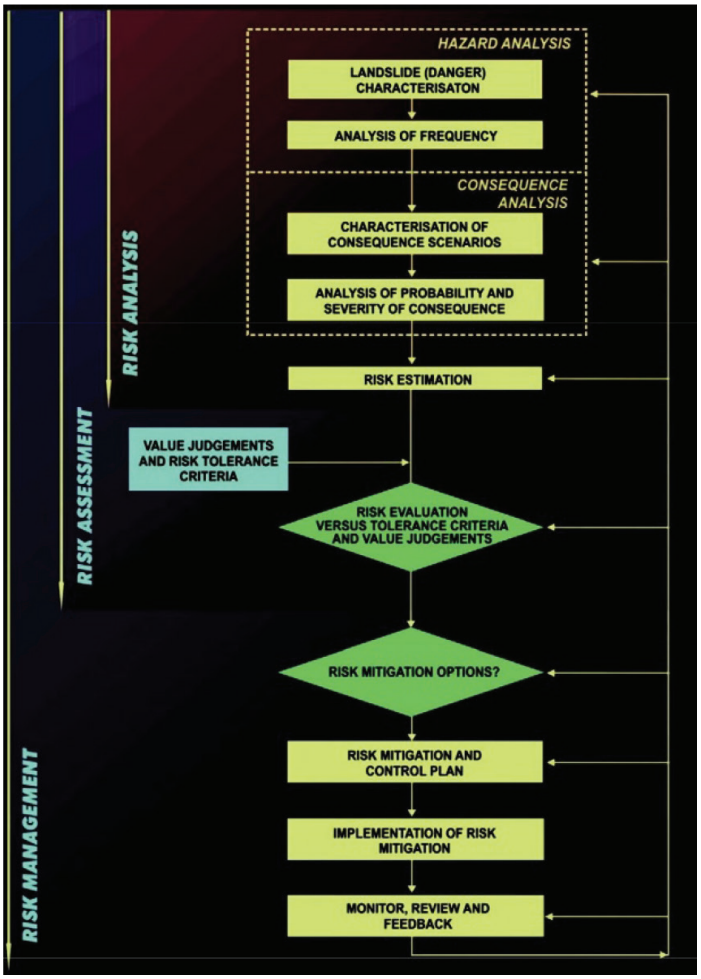
I. Generation of User-Friendly Landslide Hazard Maps

It covers aspects of reliability and validation of landslide zoning maps in the Indian scenario and proposes a future plan of activities for landslide zoning. It recommends Landslide Hazard Zonation maps to be prepared at the macro scale (1:50,000/25,000) and meso level (1:10,000). It focuses on the use of advanced state-of-the-art tools such as Unmanned Aerial Vehicle (UAV), Terrestrial Laser Scanner, and very high-resolution Earth Observation (EO) data. A suitable monitoring mechanism and quality checking option may be established at all levels to ensure the quality of deliverables.

- **Landslide Zoning** is the division of hill or mountainous areas into homogeneous spatial areas/slope according to their degrees of actual or potential landslide susceptibility, hazard or risk.
- **Landslide Susceptibility Zoning (LSZ)** uses an inventory of past landslide incidences together with an assessment or prediction of the spatial areas/slope with a likelihood of landslides in the future. Susceptibility zoning thus involves the spatial distribution and rating of the terrain units according to their propensity to produce landslides. This is dependent on the topography, geology, geotechnical properties, climate, vegetation and anthropogenic factors such as development and clearing of vegetation.
- **Landslide Hazard Zoning (LHZ)** uses the landslide susceptibility maps and assigns an estimated frequency (i.e. annual probability) to the potential landslides of a certain magnitude.
- **Landslide Risk Zoning (LRZ)** depends on the elements at risk, their temporal-spatial probability (or exposure) and vulnerability and is the ultimate aim of any zoning exercise. Administrator/Planners/Insurers are mostly interested in risk maps for their accurate planning and allocation of resources, etc. For new areas under planned developments, an assessment will have to be made of these factors. For areas with existing development, it should be recognised that risks may change with additional development and thus, risk maps should be updated on a regular basis. Therefore,

landslide zoning is always to be construed and viewed as an integral part of the broader landslide risk management framework (Fig. 4.2), proposed by Fell et al. (2005), which has widely been accepted internationally.

Fig. 4.2: Landslide Risk Management Framework (Fell et al., 2005)



In India, we must make sincere and all-out attempts to convert our susceptibility maps into true hazard and risk maps following the above-mentioned internationally-accepted methodologies. However, landslide zoning is being carried out for specific purposes and for regional, local and site-specific planning as well as safe and optimal

use of landmass. The outputs are usually in the form of one or more of the following: landslide inventory map; landslide susceptibility map; landslide hazard and risk maps; and associated reports.

a. Problem/gaps

- Landslide zoning maps so far available in India are mostly LSZ maps; however, in most of the cases, they are termed as LHZ maps despite not having any connotation about the magnitude and temporal predictions.
- The LSZ maps prepared till 2014 in India are concerned only to important route corridors and at some discrete locations (which have witnessed damage due to landslides) in some highly landslide prone States.
- Single Seamless state-wise/ district-wise landslide zonation maps are mostly not available for landslide prone northern, northeastern states and for Eastern and Western Ghats regions, which, however, this has recently been taken care of on regional/ medium scale (1:50,000) by GSI's National Landslide Susceptibility Mapping (NLSM) programme since 2014-15.
- In India, LSZ maps for the same area have also been created by different workers of different organisations following different methodologies. In such cases, which of the LSZ map is to be followed for mitigation measures is not clear to the users.
- Majority of the existing LSZ Maps are lacking details of the devastating landslide events of the past. Therefore, landslide incidence map prepared from multi-temporal and event-based sources along with its detailed geo-parametric attributes needs to be measured while ranking and weighting the thematic geo-factors for preparation of LSZ maps.
- Most of the available LSZ maps are on 1:50,000 scale because of its easy availability of source datasets and methods. But for effective developmental planning, its utility has some limitations. Moreover, on scale 1:50,000, active landslide zones of smaller dimensions having sizes of 50 m × 50 m appear as a dot (1 mm × 1 mm) on 1:50,000 scale map.
- Slope cutting and blasting activity for construction and widening of hill roads are triggering many landslides, which are in many cases merely 10-30 m wide. Such small landslides are often life-threatening on hill roads and are difficult to depict on 1:50,000 scale LSZ maps.
- From meso/large scale (1:10,000) analysis, reliance on more number of field-based inputs and analytically-determined attributes of slope forming material are needed, which are not only time consuming but also costly in nature and cannot

be implemented for large areas. Therefore, areas/sectors undertaken for 1:10,000 (meso) scale LSZ must be prioritised based on proper justification and evaluation of its risk scenarios.

- Scope of finding linkages of structural mitigation measures with meso/local scale LSZ, though difficult may be sought, so that more direct use of LSZ maps can be justified, for which some research projects can also be launched by Department of Science & Technology (DST).
- Most of the existing LSZ and landslide susceptibility maps are lacking administrative boundaries such as district, Tehsil, block and village boundaries superposed on hazard zones.
- Drainage divides are rarely shown on LSZ maps and only little drainage are shown. Hence, lack of drainage divides in general and watershed boundaries, in particular, make it almost impossible to integrate landslide mitigation measures with ongoing watershed development projects.
- Names of the elements at risk (viz. roads, canals, railway line tunnels, bridges) falling within the high, very high and severe hazard zones are missing in the existing LSZ maps.
- Existing stability measures are neither shown not mentioned in the presently available LSZ maps because of scale constraints.
- No detailed landslide inventory created on the basis of 1:10,000 scale macro-level LSZ maps is available for the formulation of landslide mitigations planning at district, Tehsil, block and village level. Therefore, landslide inventory mapping needs to be carried out at the highest possible level of larger scales (preferably 1:10,000 or larger), so that none of the smaller landslides are missed.
- Landslide Susceptibility Management (LSM) maps are not available for all areas for which LSZ maps are available. Even the available Landslide Susceptibility Management (LSM) maps are lacking site-specific structural and non-structural mitigation measures since most of such LSZ maps are on 1:50,000 scale.
- The mitigation measures recommended in the existing LSM maps are generalised ones, such as “afforestation” and “biotechnical measures” without any mention of the particular varieties of the fast-growing trees and useful grasses to be grown or list of biotechnical measures to be taken for stabilising the hill slope.
- The available LSM maps address the anthropogenic intervention (in landslide susceptible zones) very casually by suggesting measures such as “avoid further construction”, etc. This makes it difficult for the authorities to ensure strict adherence to land use regulations such as a complete ban on construction activity in a landslide hazard-prone area.

- Existing LHM maps do not address the crucial aspects of overloading and or undercutting of hill slope due to anthropogenic activities and therefore, provide no clear guidelines for removal of those manmade constructions in particular which are overloading or undercutting the hill slope or blocking, diverting or narrowing the natural drainage courses.

b. Suggestive Interventions

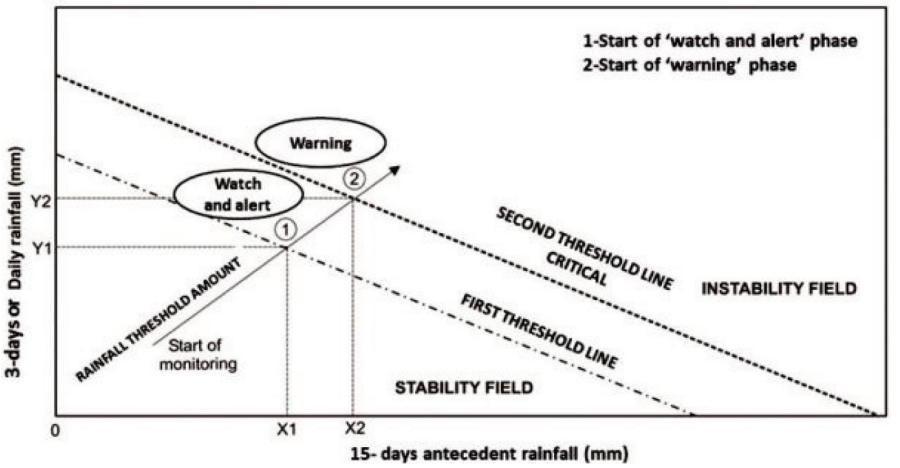
- Collection and cataloguing of all the available Landslide Hazard Zonation (LHZ) and Susceptibility Zonation (LSZ) maps, reports and atlases created by various state and central government departments, institutions and agencies, etc.
- Creation of meso level LHZ Maps on 1:10,000 scale in order to cater to the requirements of Landslide Hazard Management planning at District, Tehsil and Block level.
- Meso level LHZ Maps on 1:10,000 Scale of the already prioritised sectors should be created using very high-resolution remote sensing data, detailed field input, GPS, LiDAR and GIS techniques.
- Use of web-based and app-based dissemination tools for the preparation of maps for common use not only by the administrators but also by the community, tourists, etc.
- On macro scale (1:50,000/25,000), GSI's terrain-specific methodology followed in NLSM project can be considered as an optimal methodology pertinent to that scale. NLSM maps need to be made available in mobile phones through app-based platforms.
- Sectors for meso/large scale (1:10,000) landslide zonation preferably be chosen from the areas where previously created LHZ outputs by different agencies are available including those of NLSM, so that basic landslide and thematic database on the macro scale can be used as base maps for this study.

II. Development of Landslide Monitoring and Early Warning System

Landslides are often triggered by intense rainfall or earthquake and it is observed that seismic high hazard zones and high rainfall areas coincide with high landslide hazard zones. Therefore, for early warning of landslides in India, it is pertinent to explore both the triggering factors i.e. precipitation and seismicity.

The warning can be issued based on the actual threshold calculated with rainfall forecast. As the rainfall is dynamic, so also RT/I-D and based on exceedance of threshold values corresponding to landslide phenomena in the past, the values can be interpreted in terms of severity. In order to illustrate the above concept, methodology, as envisaged by GSI, can be cited (Fig. 4.3).

Fig. 4.3: Schematic diagram that can be used to issue a warning of rainfall-induced landslides based on rainfall threshold



During 'watch and alert' phase one has to be watchful and look for further information or if the precipitation increases then one should take action appropriate for 'warning' phase. During the warning phase, stakeholders should be ready for evacuation in high or very high hazard zones. In fact, after the 'watch and alert' warning the people should be on the alert, and start looking for signs of instability to evacuate.

This sub-group strategy highlights the past work, best practices and present status in the field of Landslide Early Warning System (LEWS), rainfall threshold-based modelling, ground-based wireless instrumentation and real-time monitoring system for landslide prediction, an earthquake triggered a landslide, monitoring mechanism of landslides and gap areas in landslide monitoring and development of early warning system. For future prospects, the technical recommendation for developing and implementing rainfall thresholds, Numerical Weather Prediction (NWP), Automatic Rain Gauges, Wireless Sensor Network (WSN), Micro-Electro-Mechanical Sensors (MEMS), etc. have been included.

a. Problem/gaps

In Indian Himalayas, the poor network of weather stations and lack of high elevation rain gauges and the collection of useful data that can help to establish meaningful relationships. Furthermore, accurate dates of landslides are seldom available due to sparsely population of the region and lack of media and official reporting of such events, although such reporting has improved in recent years.

- Well validated rainfall-threshold model is yet to be developed for all critical regions. For building rainfall threshold-based model intensity-duration (ID) based threshold, date of past landslide events and corresponding representative daily/hourly rainfall data are required. In India, except for some cases, these datasets are not easily available for the most part of the mountainous regions.
- Threshold model itself does not provide information on the spatial occurrence of potential landslides; it has to be combined with landslide susceptibility to forecast Spatio-temporal initiation of landslides.
- Information on the precise time of a landslide based on instrumentation and real-time monitoring is mostly lacking.
- In India, safe shelter and alternate route maps for landslide hazard are often not available. These maps are to be prepared for important road sections and settlements.
- Another important aspect that makes early warning ineffective is the lack of public awareness. This tends to reduce the risk by increasing awareness among the public with an aim to timely response to the warning when the disaster strikes.
- Communication of warning or risk to all concerned stake holders remains a challenge as most of the hilly area population either remains isolated, unreachable, non-responsive due to remoteness of the region or lack of awareness. Therefore, a multimedia approach involving internet portal, SMS, social media, radio and print media is required.
- Access to secondary high-quality rainfall prediction data, LHZ maps, and geotechnical data developed by other stakeholders at one platform.
- Regulation and enforcement promoting monitoring of potential/existing landslides that pose risk to life, economy and environment to large extents are weak.

b. Suggestive Interventions

Rainfall Threshold-based Landslide Early warning System (RT-LEWS)

- Database on rainfall derived from satellite and ground-based observation need to be compiled and analysed to understand variability in a region vis-à-vis landslides.
- Road/railroad maintenance records of Border Road Organisation (BRO) and railway department provide information of date and spatial distribution of landslides in the form of debris accumulated on the road but is restricted to only defined road/railway sectors. The type of data available with them also requires intense field validation before making them useable for threshold modelling.
- Compilation of landslide database with information on typology, location, date and time of occurrence. High-resolution satellite images need to be used to prepare the spatial database with good accuracy.

- Development of rainfall threshold models (I-D and antecedent rainfall based) using available information (rainfall and landslide) from IMD, BRO and other sources for regional and local level LEWS. It is envisaged to use I-D and RT-based models using data mining and statistical approaches as demonstrated by IIRS, CBRI and GSI.
- Rainfall prediction by the Numerical Weather Prediction (NWP) models to increase the lead time of early warning. The NWP models can provide very accurate rainfall forecasts 72 hours in advance over the mountainous regions.
- In order to address landslides induced by extremely localized high precipitation events known as **"Cloud Burst"**, it is desirable to increase the density of automated rain gauges (ARGs) or automatic weathers stations (AWS) in hilly regions with appropriate arrangement and analyse it on real-time hourly data or data at minute's interval using DART and I-D model.
- Wireless networking of all landslide monitoring stations and the establishment of real-time rainfall monitoring control room. Also, the development of early warning communication mechanism.
- Implementation of rainfall based landslide early warning system for regional and local use i.e., Alarm/broadcasting system for traffic control on hill roads/highways during monsoon seasons and community use in hill habitats for landslide risk reduction.
- The threshold model, as established for different regions, can be used to calculate the probability of landslides based on predicted rainfall and its accuracy would be as good as rainfall prediction accuracy which is improving significantly due to better weather forecast models. Rainfall forecast can improve significantly by using Doppler Weather Radar (DWR), which can further help the landslide prediction and early warning.

Ground Instrument based landslide early warning system (GI-LEWS)

- Selection of problematic severe landslides for instrumentation in different parts of hill states.
- Preliminary deformation monitoring using GNSS.
- Investigation of landslides and finalisation of the scheme of landslide instrumentation using cost-effective smart techniques including space technology.
- Wireless sensor network (WSN) based instrumentation and real-time monitoring of landslides.
- Greater emphasis should be on MEMS-based sensors (e.g. accelerometer, soil moisture sensor, force sensor, tilt sensor, etc.).
- Periodic data capture and analysis to develop multi-parametric threshold models for landslide early warning.

- Validation of landslide early warning thresholds and models.
- Development of early warning communication mechanism.
- Implementation of instrumentation based landslide early warning system for societal use.

Seismicity induced landslide EWS (SI-LEWS)

- Selection of study area and compilation of seismic data and early records of Seismic Induced Landslide (SIL).
- Preparation of surface geological map and good quality slope map from DEM.
- Geotechnical characterisation of surface geological materials.
- SIL modelling for simulated events and result validation.
- Deployment of MEMS-based seismometers and accelerometers for real-time warning.

III. Awareness Programmes

The role of concerned State/UT's authorities and local communities are essential not only in the preparedness and mitigation phases of disaster management but, also in the emergency situations during the event. Awareness and capacity development programmes will be successful if the involvement of local communities and authorities such as District Administration, Panchayati Raj Institutions and local communities are maximized.

The sub-group strategy spells out the need of awareness programmes, review of past work and best practices, identification of gaps, as well as recommendations and implementation strategies. It aims towards a culture of awareness generation and preparedness; so that people in the society become alert and aware in case of an emergency or take some preventive measures before the disaster strikes. A participatory approach has been defined so that each section of the community is involved in the awareness drive. Since the community is the first to confront the disaster before any aid reaches them, a mechanism of awareness is framed to involve and educate the community.

a. Problem/gaps

Bringing all the stakeholders of society together helps to ensure the durability and the expansion of landslide risk reduction in society and also other geographical areas by involving the local people considered as catalysts of change. The active engagement at the global level, linking and integrating their best practices by supporting technical

experts tend to strengthen the knowledge dissemination channels on landslide risk mitigation and encourages further awareness among all the different stakeholders on the landslide risk situation. Subsequently, disaster risk adaptation mechanisms can be expanded swiftly and more easily to other types of risks.

- Classification of the States which are prone to landslides according to severity.
- Need to study the socio-economic profile of the communities residing in these areas.
- Awareness programmes and campaigns are to be conducted on regular basis. A major drawback of the system is that awareness programmes do not reach the community vulnerable to the disaster. A comprehensive awareness outreach is to be established.

b. Suggestive Interventions

- Involvement of local masses.
- Enhancement of education focusing upon youth especially.
- Involvement of educated mass for creating awareness amongst local people and school children.
- Promotion of the latest technology and techniques.
- Creation of common signage for landslides prone area across the country.
- Toll-free number for landslide reporting.
- Use of posters and hoardings.
- Use of Disaster Preparedness and Disaster Response Apps.

IV. Capacity Building and Training of Stakeholders

In India, the need for Capacity Building and Training of the stakeholders in landslide risk management was realised not long ago. The realisation came after two tragic events of Okhimath and Malpa landslides during in August 1998.

This sub-Group strategy highlights the past work, gaps, implementation strategy, financial implications and monitoring mechanism for capacity building and training in landslides. The key recommendations include a nationwide Training Need Assessment (TNA) in Landslide Risk Management and Inclusion of new technology inputs for capacity building and training programs on landslide DRR. It also focuses on identifying targets group for training on landslide DRR and most importantly, strengthening the response framework through capacity building and training of vulnerable communities at the grassroot level.

a. Problem/gaps

- A comprehensive training needs assessment at various levels of administrative hierarchy viz. National, State, District, Tehsil, Block and Village level needs to be

conducted in all landslide-prone states. Different training modules should be prepared for each level, and the frequency of training in each region should be mentioned as part of a capacity-building action plan.

- Trainees viz. disaster managers, planners, decision-makers, an official of line departments, engineers, NGO and CBO representatives and locals participating in a training programme on landslide DRR require a precise site-specific overview of landslide hazard, causes, vulnerability, risk and required mitigation measures. This type of information can be provided to the stakeholders only through meso and micro level LHZ/LSZ maps. Scientists and social workers emphasize the need for user-friendly validated maps of landslide hazard, data inventory, models, etc. in the hands of disaster managers.
- There is no institutional framework for the collection and preservation of basic landslide data. Similarly, the inventory maps of landslides are being prepared by different agencies in a scale not generally usable on the ground. Therefore, capacity building of professionals in the line department of States/UT's will be carried out for the creation of uniform landslide catalogue and mapping.
- No dedicated project for the training of professionals such as Civil Engineers, Geologist, Geotechnical Engineers, Disaster Managers, etc. as trainers for mitigation and management of landslides to reduce risk in collaboration with other national and international agencies by involving new tools and methods. Formulation and implementation of mitigation projects are invariably left to be carried out by the State governments.
- Most of the training programs on landslides DRR have generalised contents dealing more with the concept, definitions and types of landslides, etc. Case studies indicating effective preparedness, mitigation, response, recovery and rehabilitation pertaining to a landslide event are missing in most of the training programmes.
- Fewer training programs are organised at village and ward level. Training programmes at the village level are not linked to any financial incentives and the villagers attend these programmes at the cost of their daily wages or farming hours.
- There are virtually no training on landslide safe site selection for construction of new houses. Remedial measures using the local slided material for instant temporary stability.
- There is a lack of initiative to combine the modern technical knowhow with the coping mechanism of local communities developed by them through experiential learning of generations.

- Educating local women as key stakeholders need to be promoted, as women and children tend to be victims of hazards, but can also be more effective change-makers in the community.
- Educating locals about the landslide dam formation and LLOF (landslide lake outburst flow) and its consequences downstream is another aspect that has not been given due importance so far.
- Lack of proper training, awareness and in many cases, ignorance, non-adherence to land use regulations have encouraged unplanned slope cutting and overloading for commercial gains. The recently enacted slope modification regulations of the Aizawl Municipal Corporation can be a good model for other regulatory bodies in landslide-prone areas to follow.
- Even though staff engineers are considered necessary in Municipalities, the position of a staff geologist, geo-morphologist is not present in the Line Department of States such as Municipalities. It is important to create staff positions in Municipalities; PWD's and districts administration with high landslide risks.

b. Suggestive Interventions

- Inclusion of new technology inputs for capacity building and training programs on landslide DRR
- Identification of genuine targets group for training on landslide DRR
- Upgradation and simplification of the contents of the training programme on landslide DRR
- Strengthening the response framework through capacity building and training of vulnerable communities at the grassroot level
- Elimination of communication gaps in reading the signs of landslides and for necessary pre-emptive action
- Provisions for financial incentives

V. Preparation of Mountain Zone Regulations and Policies

The sub-group strategy describes the formulation of land-use policies and techno legal regime, updating and enforcement of building regulations, review and revision of BIS code/guidelines for landslide management, proposed amendment in town and country planning legislation, regulations for land use zoning for natural hazard-prone areas as well as additional provisions in development control regulations for safety in natural hazard-prone areas, additional provisions in building regulations/bye-laws for structural safety in landslide hazard-prone areas.

There is no land use policy in the country at National, State and local level for implementation. The cities of the Himalayas are growing and beginning to turn into the mountains of garbage and plastic, untreated sewage, chronic water shortages, unplanned urban growth and even local air pollution because of vehicles. These towns need to be planned, particularly keeping in mind the rush of summer tourists. Many states have experimented from banning plastics to taxing tourists to better respond to these issues. But they need support and new thinking on everything on traditional architecture practices, local water management and different systems of sewage and garbage management.

a. Problem/gaps

- National Landslide Mitigation Policy (NLMP) which is a must for National Landslide Mitigation Strategy (NLMS) should be common all over the country while concerned State/UT specific landslide mitigation strategy must be developed by the State/UT and be area/problem specific but must reflect the NLMP.
- The existing bye-laws/regulations at the local body or state level should be incorporated in the NLMP and NLMS. They should not contradict each other.
- Best practices which are used to mitigate landslide at the local level and activities which can be held responsible for the landslide hazard should be documented.
- Since preventing/preparing for the landslides/slope instability is much easy and cost-effective than mitigating/reclaiming the landslide/slope instability. Emphasis must be given to prevention /preparedness in NLMP and NLMS.
- Unplanned developmental activities in mountains including huge investments in the construction of non-engineered roads in rural areas and lack of drainage which is exacerbating and increasing risk.
- The necessity of load-bearing tests, hazard zonation, slope and land-use maps to guide urban planners for clearing constructions.
- Impact of landslides on rural communities where the loss of large areas of farmland has ruined livelihoods and puts a big question mark on food security in the mountains. Compensation for land lost in landslides for farmers needs to be addressed.
- The necessity of DDMAs to apply for and utilise disaster mitigation funds.
- DDMA to obtain land-use, asset and other useful maps from West Bengal State Remote Sensing Centre.
- Need to focus on implementation and enforcement of laws/regulations and accountability.

- Need for better coordination between the Panchayats, Line departments, Forest department and Municipal authorities for management of jhoras and drainage outside municipal limits.
- State-specific landslide mitigation strategies to be formulated to address specific issues of each mountain state.
- Urban centres and towns in mountain areas being burdened beyond the carrying capacity by tourism and rural-to-urban migration. Need for satellite towns.
- The municipal bye-laws must provide for construction activity to be regulated in areas, which fall in hazard zones or areas close to rivers, springs and watersheds of the towns. In many cases, these provisions exist in the bye-laws but have not been strictly enforced.

b. Suggestive Interventions

- **Policy Level Intervention**
  - Government Orders issued by the various State Governments contain a number of provisions to be followed while sanctioning the building plans by the Development Authority, Special Area Development Authority, Corporation, Municipal Board and also by the concerned government department while selecting the site for construction the building. Due to the lack of technically qualified manpower either with the sanctioning authority implementation is very difficult and could not be followed. The State governments/Sanctioning authorities should have a panel of reputed and technical personnel including SDMA, who can assist as and when required to the building sanctioning authority.
  - Central government may consider giving suitable incentives for adopting landslide safe construction.
  - Necessary amendments in Section 26 of Special Area Development Authority Act 1986, as provided in Section 28 (k) of UP Planning and Development Act, 1973, regarding sealing of building, should be made.
  - It is observed that most of the government projects are outside the purview of sanctioning authority. Therefore all such projects when designed should take care of safety provisions and certified by the concerned architects/engineers.
  - At present, there are number of Acts/Rules/Regulations applicable in the states. There should be single legislation to control development and building activity which could be formed taking into consideration the present legislative framework and incorporating the suggestions made.

- Government and government agency buildings, which are designed by the Government technical department should follow strictly the provisions suggested for safety against natural hazards.
- Buildings constructed under the Pradhan Mantri Awas Yojana (PMAY) and other Government Schemes should strictly follow the provision of Indian Standards.

- **Technical Level Intervention**
  - As most of the government projects like hospital buildings, schools and others are of standard 'type' design, the provision of structural safety against natural hazards should be reflected in all such project in the drawings, and used/ implemented on the site.
  - Government departments like PWD/ Rural Engineering Services (RES) should incorporate in their curriculum related to the construction of buildings, the requirements of IS4326. The corresponding schedule of rates should also include the detail of additional features which are required to be done as per IS 4326.
- **Community Level Intervention**
  - Standard Building Plans, having provision of safety should be made available at the community level, which may consider standard house design of different types of plots, community halls and other common use buildings.
  - There is a need to bring awareness at all levels of society, first of all, a high-level awareness program for decision-makers regarding safety against natural hazards.
  - Awareness/training program is also required to be systematically arranged for engineers/officials working with local authorities regarding safe site selection, construction, bye-laws, regulations, quality control etc.
  - To further increase awareness at the Community level in rural areas, combined training of BDOs/ADOs at district level should be arranged. BDOs should be capacitated to further train people at the block level.

VI. Stabilization and Mitigation of Landslides and Creation of Special Purpose Vehicle (SPV) for Landslide Management

The sub-group strategy document emphasized on problems, gaps in Standard Operating Procedure (SoP), suitable methodology and mitigation of critical landslide. The sub-group strategy aims at providing necessary full techno-financial support to landslide-prone States,

who would submit Detailed Project Reports (DPRs) to project sanctioning agency for taking up site-specific landslide mitigation measures. Landslides are site-specific in nature and since the vulnerability is different in different locations, the methodology/ technology for mitigation of each landslide will be different, involving different activities.

The design and construction part of the protective structures for landslide mitigation may be undertaken by the concerned Department of the particular State such as PWD and if required they can approach the technical expert institution for necessary technical advice. The present engineering practice relies on fragmentary approaches involving quick-fix treatments of landslides, which end up in their recurrence, year after year, at the very same locations. The paucity of funds, absence of delivery capacity, and urgency to deal with immediate landslide danger are generally cited as reasons for this continuing practice. The permanent solutions to our major landslide problems may appear at the face value to be capital intensive and even unaffordable, but in the true analysis, the benefits of permanently fixing landslides will far overweigh. Presently, geotechnical engineering practice is sufficiently advanced to blend the short and the long term recommendations in a design package by taking recourse to the well established observational method of design and construction. This method makes use of field observations and their analysis during the process of implementation to alter the design as the work proceeds. Therefore, it is necessary for the creation of Special Purpose Vehicle (SPV) and Centre for Landslide Research Studies and Management (CLRSM) to create a techno-scientific pool of expertise in the country. Necessary geotechnical/geological studies required to prepare the DPR may also be allowed to prepare by suitable and authorised technical concerned Department/consultant group of the State government.

a. Problem/gaps

- Scattered pool of expertise and peace meal project mode work by expert institutions.
- Strengthening education, research and training in landslide mitigation and management of professionals, State Officials and other stakeholders.
- Lack of pace-setting best practices of landslide treatment/mitigation.
- Updation of Science-Technology-Innovation based holistic, eco-friendly and sustainable approaches in addressing landslide mitigation and management.
- Non-coherence of landslide mitigation with the challenges posed by extreme weather events, natural resource management, urbanisation, industrialisation and constructions that unfortunately remain largely unregulated.
- Lack of mainstreaming of landslide mitigation with environmental protection and development planning.

b. Suggestive Interventions

- **Preparation of methodology/SOP for identification of most vulnerable landslide sites in States for mitigation purpose**
  - A National Task Force of expert/committee of professionals should be constituted to catalogue, study and decide management strategies for all the known problematic landslides in the country in consultation with the State governments, district administration and the civil society.
  - Appropriate agencies, institutions and teams should be identified, shortlisted and mandated to implement the programme in a phased manner.
  - Rational criteria to classify an individual landslide as minor, medium or major should be prescribed at the outset for uniform adoption and
  - Adequate funding should be provided through national landslide mitigation and management projects or by one-time funding from the Central government.
- **The suitable methodology for planning, engineering and control measures for the execution of landslide stabilisation work and tools/methods for monitoring, inspection, audit and timely lines for completion of the work.**
  - Site-specific landslide stabilisation and mitigation of problematic landslides and reconstruction-rehabilitation of the affected community by State government's.
    - Preparation of DPRs on the basis of NDMA Template by the States/ Agencies.
    - DPR's will be scrutinised by the Group of Experts on the basis of Cost-Benefit Analysis (CBA).
    - Monitoring, inspections & audit of mitigation work by Expert Group.
- **Need for Procedure for specialised training of professionals/personnel in landslide mitigation and management at the national level.**
  - There is an urgent need to devise procedure and well-defined mechanism to impart specialised training professional and personnel dealing with landslide mitigation and management. The proposed CLRSM will facilitate and create guidelines, procedure and will impart specialised training to enhance the functioning level of various professional, State government officials and other stakeholders.

Outcomes

The strategy document is a small but significant step towards mainstreaming and strengthening of landslide disaster risk reduction (DRR) in disaster management activities

to reduce risk and minimise losses. The strategy document could provide guidance to the concerned States/UTs, Ministries/Departments and other stakeholders during conceptualisation/finalisation of their developmental projects. It will also serve as a guidance for the SDMAs/DDMAs in formulating their disaster risk management initiatives.

Conclusion

The need for formulation of a national and local level strategy for landslide risk reduction was felt. This strategy is also fulfilling the fifth target of Sendai Framework for Disaster Risk Reduction (2015-30) i.e., Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020. Strategy document addresses all the components of landslide disaster risk reduction and management such as hazard mapping, monitoring and early warning system, awareness programmes, capacity building and training, regulations and policies, stabilisation and mitigation of landslide, etc. This strategy document envisages specific recommendations for the concerned nodal Agency, Ministries/Departments, States and other stakeholders, so as to avert or reduce the impact of future landslide calamities. For any further study on National Landslide Risk Management Strategy and reference a detailed version i.e., the strategy document and compendium may be referred.

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