



Organization Logo



Photograph

Landslide Disasters in Western Ghat : Need of identifying Causes, Effects & Protective Measures

Name: Shobhan Kelkar², Akshay Wayal², Dr. M. B. Kumthekar³

Shri J.J.T. University¹, Smt. Kashibai Navale college of Architecture², Rajasthan. V.N.I.T., Nagpur³

shobhan.kelkar7447@gmail.com, akshaywayal69@gmail.com, kumthekarmb@yahoo.com

Abstract:

India is having a wide range of topographical variations. There are various mountain ranges as well as small hilly areas. Landslides, one of the geological hazards, in elevated topographical areas are causing massive losses to human being and property. In India various mountainous areas are prone to landslides. The highly sensitive areas are Jammu & Kashmir, Himachal Pradesh, North East Himalayas, Western Ghats & Nilgiri Hills.

The state Maharashtra is having one of the longest mountain range i.e. part of Western Ghats (Sahyadri ranges). Many areas of these ranges are developing & also upcoming as tourist destinations. These unplanned & unorganized development have adverse effects & results in landslide disaster. Though the landslide is one of the major natural disasters or as a result of other calamities like earthquake, rain cloud burst, jungle fires, floods et cetera, due to human intervention in these hilly areas, now it became a man made disaster. Avalanches have triggered enormous no.s of casualties & huge economic losses in these mountainous areas. Hence it became a crucial to investigate the sources & reasons of the disaster & identify the preventive methods along with periodical supervision. This paper focuses on data collection of such disasters, identifying the reasons & further designing of protective measures to avoid such kind of disasters in future.

Key words:- Landslide, Disaster, Human Intervention, Losses, Preventive measures

1. Introduction:

India has a wide range of topographical variations. There are various small hilly areas along with mountain ranges. Avalanches in India are considered a major hazard in most hilly & mountains regions & also in steep river banks & coastlines. Various mountainous areas are prone to landslides.

Landslides, one of the geological hazards, in elevated topographical areas are causing massive losses to human being & property. The major areas affected by landslides in India are split mainly in to regions as landslide-prone areas in India. These are based on landslide hazard zonation:

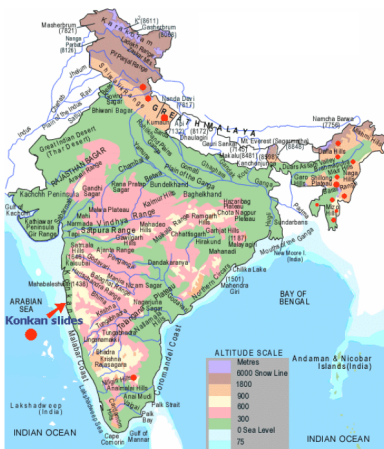
(UGC Care Journal)

- The Western Himalayas (in states of Uttar Pradesh, Uttaranchal, Himachal Pradesh & Jammu & Kashmir)
- The Eastern & North-eastern Himalayas (in states of West Bengal, Sikkim & Arunachal Pradesh)
- The Naga-Arakan Mountain belt (in states of Nagaland, Manipur, Mizoram & Tripura)
- The Western Ghats region including Nilgiris (in states of Maharashtra, Goa, Karnataka, Kerala & Tamil Nadu)
- The Plateau margins of the Peninsular India & Meghalaya plateau in North-east India.

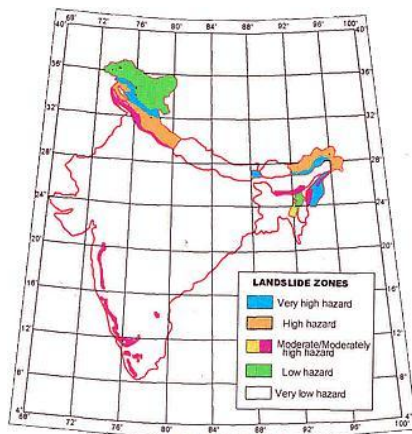
2. Western Ghat of India:

The Western Ghats are similarly known as Sahyadri. These are a north-south series of mountains or hills parallel to the western coast of the India & mark the west side boundary of Deccan plateau area. These West side Ghats contain a sequence of residual hills & peaks segregated by saddles & passes. The range are approximately 1,600 km long & passes across the Maharashtra,

Goa, Karnataka, Kerala & Tamil Nadu states & it ends at Marunthuvazh Malai, at Swamithope, near the south point of India. These hills cover up 160,000 km² & create the catchment zone for complex river. As one of the oldest mountain range with exclusive biophysical & environmental processes, the mountain range of Western Ghats signifies geomorphic features of great significance. As the average elevation is around 1200 m, the Western Ghats block southwest monsoon winds from reaching the Deccan Plateau. The Western Ghats' forest ecosystem influence the Indian monsoon pattern. The geology & geomorphology coupled with high rainfall makes the Western Ghats as one of the most ecologically diversified landscapes.



Map of areas prone to landslides in India



Landslide zones map (Source: National Disaster management authority)



Western Ghat map (Source: REPORT OF THE HIGH LEVEL WORKING GROUP ON

(UGC Care Journal)

WESTERN GHATS, Ministry of Environment & Forests Government of India 15 April 2013)

Tremendously intense precipitation, humid environment & other geological & climatic elements are affecting the stability of the range. During monsoon series of small & most important avalanches are a common occurrence in the area. These landslides often cause severe environmental problems in terms of loss of life & property as a result of increasing population density, intense economic & natural resources' mobilization activities in these region.

3. Landslide

Landslides, as one of the major natural hazards, account each year for enormous property damage in terms of each direct & indirect costs. Avalanches can happen in isolation as well as along with or as a result of other disasters like earthquakes, floods, lightning, cloud-burst, jungle fires, dam / lake bursts etc. Avalanches often cause large-scale socio-economic destruction including loss of life & social damage along with impair the operation of crucial infrastructure & destroy social heritage & ecological systems. Avalanches, defined as the movement of a mass of rock, debris or earth down a slope (Cruden, 1991).

The triggering factors for avalanche are severe rainfall, earth shaking, water level change, hurricane waves or rapid stream erosion that cause a quick increase in shear stress / decrease in shear strength of slope-forming raw material. The term landslide or less often, landslip, refers to numerous forms of mass wasting which include a wide range of ground movements such as rock falls, deep-seated slope failures, mudflows, & debris flows. Gravity is the primary driving force for the occurrence of a landslide, but there are other factors that affect slope stability that produce specific conditions that make a slope prone to fail. In many situations, a single occurrence (such as a heavy rainfall, an earthquake, a slope cut to build a road, & many others) causes the landslide although this is not necessarily detectable.

Landslides occur when the slope (or a portion thereof) undergoes certain processes that change its state from stable to unstable. This is attributed in part to a decrease in the shear strength of the slope structure, an increase in the shear stress endured by the material, or a combination of the two. A decrease in a slope's stability may be caused by a number of causes, working together or by themselves. Causes for landslide are as follows:

a) Natural Causes:-

- Saturation by rainwater absorption
- Heavy rainfall
- Growth of ground water or change of pore water pressure
- Hydrostatic pressure in cracks & fractures
- Loss or absence of vertical vegetative structure
- Soil nutrients & soil composition
- Earthquake induced landslide
- Volcanic eruptions

b) Man made activities:-

- Logging, farming & construction
- Equipment or road vibrations
- Drilling & mining
- Earthworks (e.g. modifying the form of a cliff, or imposing new loads)
- Removal of deep-rooted vegetation connecting colluviums or bedrock in deeper soils
- Change in farming pattern or forestry operations

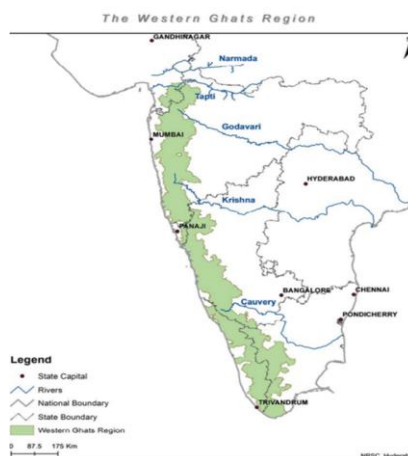
4. Landslide in western ghat

The western Ghats is termed as the most stable region, but due to uncontrolled degradation of jungle & valleys, it has become susceptible to landslides. After Himalaya, being the second most prone area to landslide occurrences, the western Ghats has always been a region of prime concern. Thick soil cover & steep slope make this area susceptible to landslides. While human being involvement is the key reason, variable precipitation pattern causing the loosening of landmass has only noticeably to the cause.

Landslides are causing disruption in communication & traffic networks in conjunction

(UGC Care Journal)

with severe harm to lives & property. Usually avalanches are triggered by heavy or prolonged rainfall. Every year because of landslides, roads remains closed for long periods & affecting the basic supplies & provisions of the affected region. Landslides disrupt water sources & choked them by debris fall. Additionally there are adverse affect on agriculture production.



Some of the worst incidences of landslides in western ghat are:

Mumbai Landslide , Maharashtra	due heavy rains which was followed by land erosion.	July 2000
Amboori Landslide, Kerala	due to heavy rains	November 2001
Marapallam landslide in Tamil Nadu	rainfall-induced	2009
Malin Landslide, Maharashtra	due to heavy rainfall	June 2013
Kavalappara landslide	The heavy rainfall that triggered this landslide	August 2019
Near Adoshi tunnel near to Lonavala on the Mumbai- Pune	During Rainfall	19 July 2015
Kozhikode, Wayanad & Kannur districts, kerala	During heavy downpour	June 2018,

Landslide Susceptibility Map (Source: Geological Survey of India)

4.1 Threats to Western Ghat

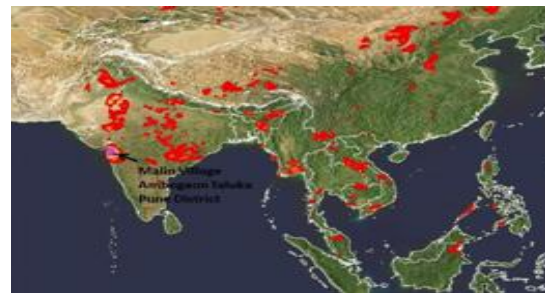
Due to uncontrolled degradation of forest & valleys, the western ghats, though called as the most stable region, it has become vulnerable to landslides. The loosening of landmass as a result of varying rainfall pattern has major factor to be considered along with human intervention is the primary reason.

Larger size deposition of dug up debris & loose top soil make the western ghat vulnerable to landslide. The widening of road works, irrigation projects, tourism activities in western ghat accelerate the construction activities resulting quarry & dumping of loose soil long the steep slopes. The stability of the region gets affected due to loose soil dumped all along these valleys gets washed away in intense precipitation of the area. The likelihood of landslide & landmass slides is 3-fold more in the areas disturbed by linear infrastructure as compared to undisturbed steep jungles. Measure threats are as follows:

- a) **Mining:** Growing mining activities often in violation of all laws are resulting in increased vulnerability to landslide along with serious & agriculture & social disruption.

- b) **Human-wildlife conflict:** Human-wildlife conflicts are a common phenomenon as the western Ghats exists within an intensely human-dominated landscape.
- c) **Changed Agriculture Practice:-** Changed agricultural practice contributed to instability of the hills.
- d) **Encroachment by human settlements:** Human settlements & construction activities of infrastructure accordingly represent a significant threat to the stability of slope.
- e) **Pollution:** Aquatic & forest ecosystems are seriously damaged due to the unlimited use of agrochemicals in the vicinity of jungles.
- f) **Hydropower projects & Huge dams:** Bigger dam projects in Western Ghats have caused in ecological & social disruption.
- g) **Deforestation:** There are negative effects of transformation of jungle land into agricultural land or for various commercial reason such as tourism, illegal logging for timber on biodiversity.
- h) **Climate change:** The variations in land use & deforestation always led to massive changes in the period & amount of rainfalls. Environment variations has been considered as a reason of floods in many regions in recent past.

- Continuous heavy rainfall from the last three to four days in the area.
- Soil saturation due to the rainwater saturated the soil along the slope of the village
- Deforestation & Leveling Of Land on the Hill or cultivation
- Wrong execution of the implementation of Government scheme
- Stone quarrying
- construction of Dimbhe Dam



Malin receives very heavy rainfall on the 29th July, 9 pm by NASA TRMM

4.1.2 Landslides at Mahabaleshwar (Aug 6,2019)

Mahabaleshwar is one of the areas of Maharashtra's Western Ghats which is often trapped by landslide. Landslide took place in several Satara sub-districts such as Mahabaleshwar, Patan, Koyna, etc. High intense rainfall, morphological condition slope & land use change were the driving factor of the event. Also land slides are caused either by natural or human intervention. Landslide occurred nearly every year in Mahabaleshwar especially during the rainy season. The data on Mahabaleshwar landslide occurred in August 2018 was causing road blockage. The city government & local population have adopted a variety of coping strategies to deal with the Mahabaleshwar landslide.



4.1.1 Landslide at Western Ghat in Maharashtra with reference to Disaster at Malin

The massive landslide wiped out the village of Malin in July 2014. Some of the key facts to noted are, heavy rainfall before the landslide (10.8 cm on July 29) & heavy downpour throughout the following day. This calamite is a lesson for sustainable geotechnical planning in future to avoid enormous loss of property & human life. High intense rainfall, morphological condition slope & land use change were the driving factor of the event.

The main reasons for the disaster are as follows:

- Changed Agricultural Practice

Debris flow along the steep road cutting

Topographic landslide locations map of the area shows steep slope around the Mahabaleshwar. (source: Journal Geological Society Of India Vol.92, November 2018, pp.555-561)

Mahabaleshwar area experiences landslides every year during the monsoon. The factors which affects avalanche processes in region are soil form, its thickness, weathering, rainfall, land use cover & anthropogenic movements. Heavy Rain affects the amount of weathering in the area. The weathering index defines the magnitude of slope instability & its failure. The surface failure sites are mainly linked with the weathered soil or red bole bed, suggesting the role of weathering. Thick lateritic & weathered soil cover at higher elevations absorbs the water, raises its pore pressure & fails as debris flow. Also joints & fractures act as passage for movement of water to lower level & erode the red bole beds resulting in rockfall in the lower elevations. Hence weathering have major influence on the landslide processes in the area.

5. Need of Disaster Management

The challenge of the landslip is serious in Western Ghat of Maharashtra mainly because of topography, human intervention, heavy precipitation etc. Upland region of Deccan Volcanic Provinces (DVP) is believed as a most vulnerable region for landslides movement in the state of Maharashtra in India. Western Ghat or sahyadri range area experiences avalanches each & every year during the monsoon. The factors which influence the landslide processes in the area are

- soil type, its thickness, weathering, precipitation, land use, land cover & anthropogenic activities.
- Monsoon influences the degree of weathering in the area. Thick lateritic & weathered soil cover at higher elevations absorbs the water,

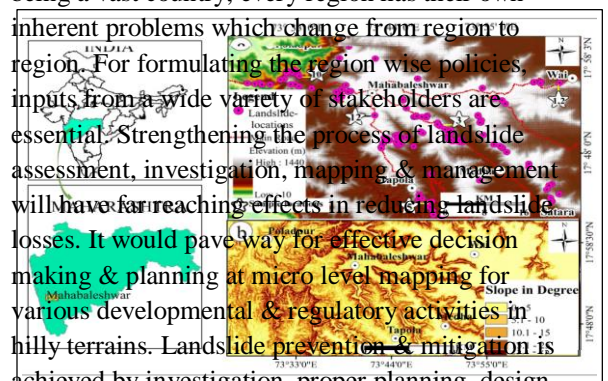
increases its pore pressure & fails as debris flow.

- The secondary discontinuities such as junctions & fractures act as pathway for movement of water to lower level & erode the red bole beds. This results in rockfall in the lower elevations.

From last decade, it is observed that the stable strata of basalt experiences the landslide hazards due to manmade activities e.g. frequent landslides on kokan railway route, Pune- Mumbai Expressway, Malin Landslide disaster.

When residents move into new regions with hilly or mountainous terrain, it is important to understand the complexity of their potential exposure to landslide risks, & how towns, cities, & counties should prepare for land-use, new construction technologies, & services that will reduce the cost of life with landslides. Landslides disaster may be a natural or manmade & the need for a national strategy has been strongly felt & worked upon. The National Disaster Management Authority through, National Disaster Policy & Guidelines, on Landslides is working on this. India being a vast country, every region has their own

inherent problems which change from region to region. For formulating the region wise policies, inputs from a wide variety of stakeholders are essential. Strengthening the process of landslide assessment, investigation, mapping & management will have far reaching effects in reducing landslide losses. It would pave way for effective decision making & planning at micro level mapping for various developmental & regulatory activities in hilly terrains. Landslide prevention & mitigation is achieved by investigation, proper planning, design & execution & proper integration of the development & construction activities. However, very little efforts towards research & development pertaining to landslide investigation has been made so far in India. There is need for landslide investigation to develop innovative, eco-friendly,



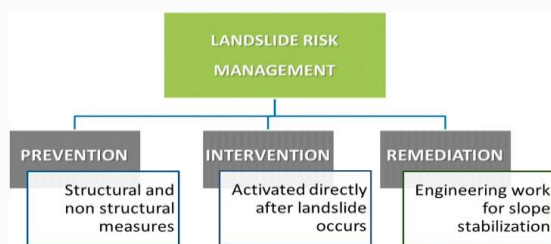
sustainable and cost effective measures for & remediation practices in reduction of negative impact & consequences of adverse events.

6. Landslide Disaster Management

The main issue in landslide disaster management is the lack of awareness among the public as well as the planners. Though the Department of Science & Technology, Government of India has suggested having raise awareness among policy makers & planners at state/district & user institution level through conducting training programmes/workshops, there should be efforts towards awareness among community leaders & general public affected by landslide hazards about the cost-effectiveness & benefits of taking landslide hazard mitigation measures.

The early warning system should be readily available for landslides like Likelihood of the occurrence of an event, the size & in a location that would cause casualties, damage, or disruption to an existing standard of safety. The landslide prone areas should be identified & a risk quantification study can be implemented for these vulnerable sites, so that this information’s can become vital in case of emergency response.

There should be approaches to identify the landslide risk & raise awareness in humans by active participation from all the stakeholders along with local & Government authorities. .



The structure of landslide risk management.

Landslides pose a serious physical & environmental threat for people living in areas

vulnerable to landslides. Some of the mitigation steps are

- a) Schemes to better understand and reduce the risk of landfill disasters should be implemented.
- b) Effective landslide risk reduction approaches consist of improving methodologies for identifying landslide-prone areas and developing strategies for reducing risk reduction.
- c) It is essential to ensure knowledge transfer & preparedness, as well as capacity building.
- d) The strategy should involve sharing research findings, insights learned & anticipated field training for experts & emergency management specialists, such as planners, engineers, architects, geographers, environmental advisors & university professors, as well as improving neighborhood readiness by engaging & informing communities.
- e) The Authority can utilize the knowledge from this work to create advanced risk management plans for landslides.

An important tool for efficient risk reduction is a building inspection system that controls built environmental systems to ensure the safety of buildings & occupants. While some of the area like Mahabaleshwar owns a building inspection program, due to its fractured nature & lack of understanding based on risk, it has been rendered ineffective. In keeping with the changing catastrophe strategies & a comprehensive & risk-based view, this program needs to be re-structured. Building practitioners who work with inspection procedures must raise awareness of a systemic understanding based on risk. Construction assessment services & ongoing professional development activities for specially trained architects are considered an important solution to holistic hazard risk reduction (HRRR). Continuing method in professional development is inefficient at the moment as it does not take a holistic approach to risk mitigation. This

(UGC Care Journal)

hinders capacity-building practices by building inspection training for architects. Continuous professional training model of the building inspection system requires a more holistic & risk-based understanding in line with shifting disaster policies & accumulating risk complexities & uncertainties in the built environment. A systematic & risk-based building inspection preparation approach is needed to deal with & that the increasing risks & uncertainties in the built environment to meet capacity development needs because it has a fragmented structure & lacks a risk-based concept.

7. Conclusion

Landslides, one of the geological hazards, in elevated topographical areas are causing massive losses to human being & property. This disaster often causes large-scale socio-economic destruction including loss of life & human injury along with impair the functioning of critical infrastructure & destroy cultural heritage & ecological systems. After Himalaya, being the second most prone area to landslide occurrences, the western Ghats has always been a region of prime concern. Thick soil cover & steep slope make this area susceptible to landslides. While human intervention is the primary reason, changeable rainfall pattern resulting in the loosening of landmass has only considerably to the cause.

There should be approaches to identify the landslide risk and raise awareness in community by active participation from all the stakeholders along with local & Government authorities. Along with the early warning system, the landslide susceptible areas should be identified & a risk quantification study can be implemented for these vulnerable sites, so that this information's can become vital in case of emergency response. The building inspection system should be effectively used for efficient risk reduction & to control built environmental systems to ensure the safety of buildings & occupants. A systematic & risk-based building inspection preparation approach deals with & that the increasing risks & uncertainties in the

built environment to meet capacity development needs.

Reference

- Mayank Joshi, Rajappan, Rajan, Mathai, Sankar, Nandkumar & V. Anil Kumar (2018), 'Weathering Controlled Landslide in Deccan Traps: Insight from Mahabaleshwar, Maharashtra, Journal Geological Society of India, Vol.92, November 2018, pp. 555-561
- Tapas R. Martha, Roy, Khanna, Mrinalni & K. Vinod Kumar (2019), 'Landslide mapped using satellite data in the Western Ghats of India after excess rainfall during August 2018, Current Science, Vol. 117, No.5, pp. 804-812
- G.P. Ganapathy & C.L. Handa, (2012), 'Landslide Hazard Mitigation in the Nilgiris District, India – Environmental & Societal Issues', International Journal of Environmental Science & Development, vol.3, No.5, pp. 497-500
- National Disaster Management Guidelines (2009), National Disaster Management Authority Government of India
- T.V. Ramachandra, Bharat H. Aithal, (2010), 26th Annual In house Symposium on Space Science & Technology, ISRO, Isc Space Technology Cal., Indian Institute of Science Bangalore
- A.F.Shaikh, P. N. (2015). Report on Landslide in Malin Village in Pune. *International Journal of Engg. Sciences & Research Technology*, ISSN:2277-9655.
- Singh, S. K. (2015). Landslide Disaster: Cause Effect & Protective Measures in India. *Journal of Civil Engineering and Environmental Technology*, 6-10.

- S.M.Sarvade, M. p. (2014). Malin Landslide: A case study. *National Conference "GEPSID"* . Ludhiana: GEPSID.
- Tikke B. B , Patil Amrut K., Chavan R. R., Ms. Desai S.S, (2014) Review Of Landslide: A Special Attention Western

Ghat Of Maharashtra, International Journal of Research in Advent Technology, Vol.2, No.3