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Vulnerability Assessment: effective tool for landslide disaster management in Western Ghat of Maharashtra

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Abstract - India has a sensational record of catastrophes. Largest parts of India, especially the Himalayas, the North eastern hill ranges, the Western Ghats, the Eastern Ghats , the Nilgiris, and the Vindhyas, affect due to landslides, as one of the major hydro-geological hazards. Prone to frequent floods and extreme meteorological conditions, Western Ghat is prone to landslide with its steep slope and thick soil cover. Unlike other catastrophes such as droughts and floods, landslides may appear to be small, but the slips along the valleys can be more incurable and may take years to recover for the people from the region. The livelihood of thousands of people get devastated along with irreversible environmental damages due to rapid erosion of natural resources of degradation of soil along the valleys. There is a requirement to propose the structures in the frames of environmental sustainability, economic feasibility and social acceptability.

It is imperative that slopes vulnerable to failure should be identified prior. In accordance with the slope stability conditions of hilly region, development activities may be planned. To access the vulnerability in terms of physical, social and economical aspects, the landslide hazard zonation map can be used so as to adopt suitable preventive measures. For this with reference to the expected degree of loss due to landslide , landslide risk should be identified. The risk is determined by the product of the landslide hazard and the vulnerability. For a landslide risk assessment, data regarding the Landslide hazard and vulnerability are important. This is useful for planning appropriate defining strategic goals of Societal improvement & its environmental surroundings by helping the policy makers in making the implementation policies.

Keywords - Landslide, Western Ghat, Risk, Hazard, Vulnerability

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INTRODUCTION

Due to the pull of gravity, the rapid mass movement of mud, soil and /or rocks downhill is known as a landslide. Landslides are disasters, frequently occurring and in a variety forms. Though these are one of the natural hazards, many times landslides can happen in conjunction with or as a consequence of other disasters like cloud-burst, earthquakes, forest fires etc. Most landslides occur gradually, but some may occur sudden. Unlike other catastrophes such as droughts and floods, though landslides may appear to be small, the slips along the valleys can be more incurable and may take years to recover for the settlement from the region. Along with irreversible environmental damages, the livelihood of thousands of people get devastated due to rapid erosion of soil and degradation of natural resources along the valleys.

As frequent incidences of erosion and other slope failure, due to varied natural or manmade activities, are noticed, there is a crucial need to identify the slopes vulnerable to failure prior, so as to take appropriate measures to check the failure processes. Accordingly the development activities may be

planned with the slope stability conditions of hilly region.

Prevention Before landslide disaster

- Ground assessment should be done prior to development and construction so as to know the kind of soil type, susceptibility to ground movements and possibility of landslides.
- Need to find out suspect ability to landslides. If previously occurred landslides have noticed in the area , there would be the high chances of another landslide occurring in future, as landslides usually occur in the same areas.
- If the area is at high risk, an evacuation plan should be prepared
- To stabilize soil on the slopes of your property, Plant trees and other types of vegetation
- Notice the changes to surroundings that may signals the likelihood of landslide activity e.g. leaning fences or walls, widening of slips etc.

For this there is need to do vulnerability assessment which will help to identify the relationship between exposure to landslide risk event, the impact of that and the ability of the system to cope with the impacts or the efforts needed to minimise the impacts.

METHODOLOGY FOR VULNERABILITY ASSESSMENT

In general terms, the degree of loss to a given element or set of elements at risk within the area affected by a landslide is known as vulnerability. Generally vulnerability is expressed as no damage, some damage, major damage and total loss or by a numerical scale of 0 (no damage, 0%) to 1 (total loss, 100%). On the basis of exposure to risk and an inability to avoid or absorb potential harm, vulnerability can be defined . Physical vulnerability is defined as the vulnerability of physical environment; social vulnerability as experienced by people and their social, economic and political systems; and human vulnerability as the combination of physical & social vulnerability. Vulnerability depends upon:

- The capacity of characteristics of a group or person to anticipate, cope with , resist and recover from impacts of a hazard;
- Susceptibility and the degree of resilience of the community and environment to hazards; and
- Social, physical, economic and environmental factors and a human condition or process resulting from the same which determine the likelihood and scale of damage from the impact of a given hazard.

Vulnerability is a set of prevailing and consequential conditions-physical, social and attitudinal which adversely affect the community's ability to prevent, mitigate, prepare and respond to the impact of a hazard event. It can be defined as the ability of an element at risk to withstand mass movement of a given dimension. Vulnerability is defined in terms of susceptibility, exposure and coping capacity which can be expressed mathematically by equation

$$\text{Vulnerability} = \frac{\text{Susceptibility x Exposure}}{\text{Coping Capacity}}$$

Factors Affecting Vulnerabity

Physical Factors	Refer to considerations and susceptibilities of location, the built environment
Social Factors	Well being of individuals, communities and society
Economical Factors	Economic status of individuals, communities and nations
Environmental factors	Extent of depletion of natural resource and the state of resource degradation.

Parameters Of Landslide Vulnerabilty

Landslide Vulnerability	
Geo –environmental Parameters	**Socio Parameters**
• Geology, lithology and structure • Hydrogeology & hydrological conditions & drainage patterns, Rainfall intensity • Slope morphometry, slope shape, slope angle, aspect • Geomorphology • Land use, Land cover, agriculture and forestry • Relative relief	• Population, population density • Settlement and urban sprawl • Psychological • Type of agricultural and forestry, eco-tourism • Infrastructural development, transportation facility • Institutes, educational facility • Civil engineering constructions, type of construction, industry

METHODS OF VULNERABILTY ASSESSMENT

Qualitative assessment **:- This approach is based on the experience of the experts and the risk areas** are categorised with terms as very high, high, moderate, low and very low risk. Qualitative assessment is defined as considering classes for magnitude, probability, hazard, vulnerability and specific risk. Using satellite images, anaglyph and field mapping, the changes of distribution and shape of landslides can be represented to assess their expected frequency occurrence and intensity.

Quantitative Assessment:- This aims at quantifying the risk and used for specific slopes or very small areas using probabilistic methods.

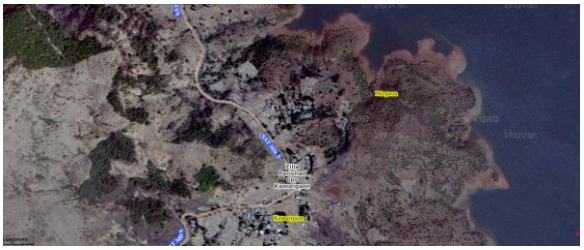
Risk= E X P X V where, E= elements at risk (value), P=Probability of hazards, V= Vulnerability

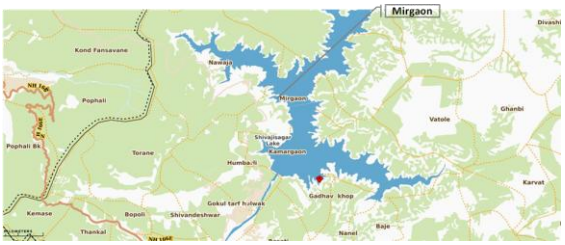
This approach is having combination of hazards as probability of sliding and vulnerability as consequences

Semi- Quantitative:- Generally this is used for medium scales. Now a days such approaches can efficiently use spatial multi-criteria techniques implemented in GIS that facilitate standardization, weighting and data integration in a single set of tools.

VULERNAILITY ASSEMENT AT Mirgaon, Patan Tahsil, Maharashtra

Mirgaon village (17º25'34"& 73º 44' 51" E)is located in Patan Tahsil, Dist. Satara, Maharashtra. This is a small village near Koyananager dam & Ozarde waterfall. During the torrential rains in July 2021, landslide incidence occurred at Mirgaon which caused major damages to village. During the visits information was collected regarding population types and details of building, transportation system, details of lifelines such as water supply, electricity, communication network, medical and education facilities etc. The information of the landslie event was also collected in terms of nature and cause of occurrence number of lives suffered details of damaged buildings, roads lifelines, essential facilities and an environmental damage due to erosion in turn degradation of disturbed ecosystem





Source:- https://bhuvan-app1.nrsc.gov.in/state/MH#

In this research work, the qualitative method is used. All information gathered in descriptive type or categorized in terms of very high, high moderate, low and very low type damage etc. which is considered a number of factors that have an influence on vulnerability. A score ranges and settings for each factor may be used to assess the extent of the factor; favorable or unfavorable to the occurrence of landslide hazards and losses or damages consequences the matrix of hazards consequences is used to obtain rank value.

Building types with its resistance and damage

Sr. No.	Types of Building structure	Resistance	Damages
1	Stone masonary with cement mortar	Less	Major- Collapse of walls & Roof may occur
2	Load bearing structures of brick walls	Medium	Partial Damage- Collapse of walls with damage to roof
3	RCC framed structures	High	Minor Damage – Cracks occur in walls and or roof

Physical vulnerability

Types of physical vulnerability	Description	weights
Building Vulnerability	Stone masonary with soil mortar with sheet roofing	0.9
	Stone masonary with cement mortar with sheet roofing	0.8
	RCC framed structure	0.6
Transportation vulnerability	Bitumen paved road	0.8
	Unpaved road	0.1

Severity levels with its description

Severity level	Description	weights
1	Life threatening experience	0.4
2	Homeless	0.5
3	Minor injury without hospitalization	0.6
4	Major injury requiring hospitalization	0.7
5	Death	11

Affected structures with types of structure and its damages

Structural Damages	Structure Type	Affected Houses
Major Damage	Stone masonary with cement mortar	20
	Load bearing structures of brick walls	15
major damage	RCC Framed structure	2
Total		37
Partial damage	Stone masonary with cemet mortar	5
	Load bearing structures of brick walls	4
	RCC Framed structure	-
Minor damage	Stone masonary with cemet mortar	10
	Load bearing structures of brick walls	5
	RCC Framed structure	4
	Total	27

Illustration of life line & essential facilities types with its weights

Types of Vulnerability	Description	Weights
Economic Vulnerability	Agricultural sector	0.90
	Tourism sector	0.30
	Services	0.10
Economic vulnerability		0.43

Illustration of environmental vulnerability

Types of Vulnerability	Description	Weights
Environmental Vulnerability	Land cover	0.35
	Natural drainage	0.45
	Cultural heritage	0.20
Environmental Vulnerability		0.33

Overall vulnerability

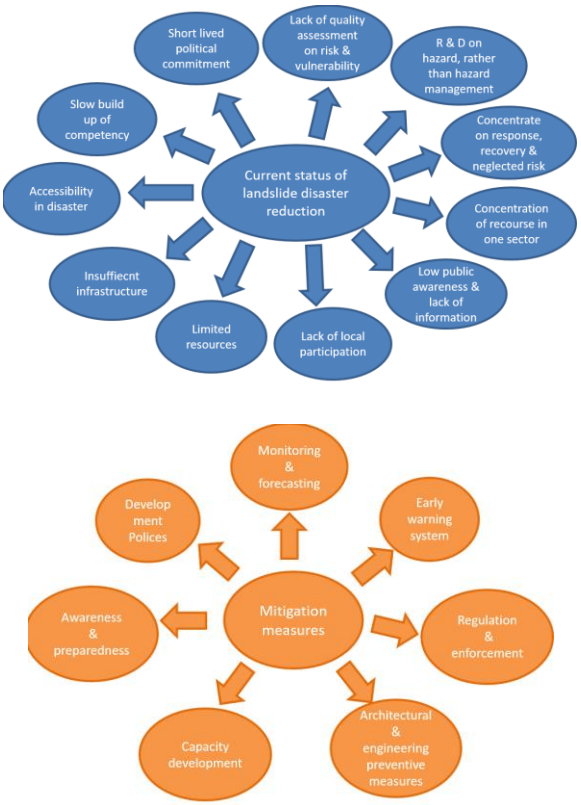
Sr. no	Types of vulnerability	weights
1	Social Vulnerability	0.66
2	Physical Vulnerability	0.57
3	Economical vulnerability	0.43
4	Environmental vulnerability	0.33

Due to more valuable, social vulnerability is given more weights and after that for survival of human being the importance is given to physical

vulnerability. Other essential aspects are economy and environment so that economical and environmental vulnerability are considered after physical.

MITIGATION

The obtained vulnerability assessment data incorporated unnoticed area of Mirgaon and reflected risk for nearby settlements. More destruction, damage and loss are there as per the results; therefore the study is useful for rehabilitation of Mirgaon village on stable ground at earliest. The basic problem noticed in the study, is intensive weathering action and rainfall in short duration. Being a earthquake prone zone, earthquake intensity and frequency is a major factor to be considered.



Current status of landslide mitigation

NEED OF LANDSLIDE MITIGATION

The occurred landslides may be reactivated during the mansoon as geotechnical properties indicated no stability for increased moisture content. Reactivation may be much more vulnerable than previous one because future movement might act like a toe failure of undisturbed soil stratum . The rehabilation of the settlement at such location should be avoided. There is a need to prevent any further movement of soil. Some of the preventives measures are:

- Mapping and demarcating landslide prone areas along to help the future development activities
- Development of early warning system
- Design of surface and sub surface drainage system to reduce the water content or pore pressure of the rock or soil
- Providing additional material at foot of the slope
- Reduction of loading such as debris, soil deposits or built structures on inclined areas
- Slope stabilisation
- Appropriate designing of retaining wall considering the load and slope
- Divert the surface runoff above the slope by use of impermeable material
- Strengthening of slopes
- Use of horizontal RCC bands in building construction with pile foundation
- Avoid Excavation and back filling

CONCLUSION

Due to varied natural or manmade activities and erosion, slope failure processes are the most frequent. The causes of landslide disaster widely vary depending on soil type, geology, morphology, terrain shape, steepness of slope and whether the affected areas inhabit people or structures. It is imperative that slopes vulnerable to failure should be identified prior. By effective vulnerability assessment and accordingly risk evaluation, vulnerability towards landslides can be reduced by creating a culture of safety through land use planning, timely and appropriate engineering intervention, conscientious maintenance of slopes and connected utilities, early warning systems, public awareness and preparedness.

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