IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, September 2022
Impact Factor: 6.252

Research Paper on Science Research for Infrastructure Improvement in the Wake of the Landslide Disaster

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Abstract: *One of the major natural disasters, landslides cause tremendous property damage each year, with both direct and indirect expenses. As a catastrophic phenomenon, landslides frequently result in extensive socio-economic destruction, as well as fatalities and serious injuries to people. Additionally, landslides disrupt ecological systems, damage cultural artifacts, and interfere with the operation of vital infrastructure. Most estimates of landslide losses that have been reported turn out to be much lower than the actual effects of landslides on society as a whole. Landslides represent a rising risk to human life, buildings, structures, infra-structures, and biodiversity with increased population and human interventions in terms of developmental activities over unstable slopes. High vulnerability to landslides has resulted from widespread deforestation and poor management techniques in many areas.*

Keywords: Landslide, infrastructure, losses, Human Intervention, Hazards, vulnerability

I. INTRODUCTION

India has a horrifying track record of landslide-related disasters. The Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats, as well as the Vindhyas, are among the most significant hydro-geological hazards that can affect significant areas of India. One of the major natural disasters, landslides cause significant property losses each year in terms of both direct and indirect expenses. Landslides can occur not just on their own but also as a result of other natural disasters such as earthquakes, floods, lightning, cloud bursts, forest fires, dam/lake bursts, etc. Landslide losses in such disasters are often handled along with the initial disaster and are not handled separately.

Defining landslides as the movement

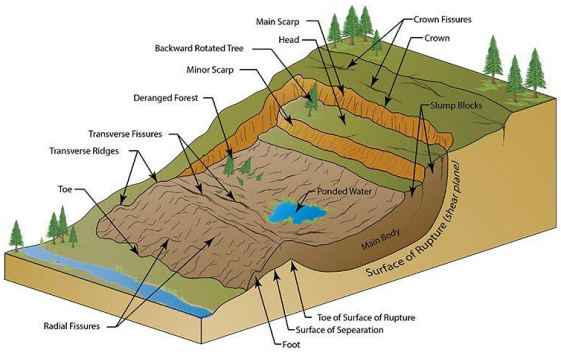

Figure 1: Morphology of landscape

II. CLASSIFICATION OF LANDSLIDES

A classification of landslide is based on Varnes and Cruden (1996) system as the material type and movement type

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2.1 Material Type

A	Rock	Hard or firm mass that was intact and in its natural place before the initiation of movement
B	Soil	An aggregate of solid particles, typically of minerals and rocks as a result of weathering of rocks in situ.
C	Earth	80% or a lot of particles are smaller than 2mm
D	Debris	Significant proportion of coarse material; 20% to 80% of the particles are larger than 2mm.

2.3 Type of Movement

The categories of movement describe however the landslide movement is distributed through the displaced mass. The five movements are as follows:

A. Fall

Fall may be a extreme rapid to very fast movement that starts with detachment of material from steep slopes like cliffs, on a surface on that very little or no shear displacement takes place. The Material then descends through the air by free falling, bouncing or rolling onto the slope below:

- The detachment of soil or rock from a steep slope on a surface on that very little or no shear displacement takes place
- Movement very rapid to extremely rapid
- Free fall if slope exceeds 76 degrees and rolling at or below 45 degrees.

B. Topple

Topple involves overturning of material. Topples vary from very slow to very fast movements.

- The forward rotation out of the slope of a mass or a rock a few purpose or axis below the centre of gravity of the displaced mass
- Movement varies from very slow to very rapid
- Driven by gravity and generally by water or ice in cracks in mass

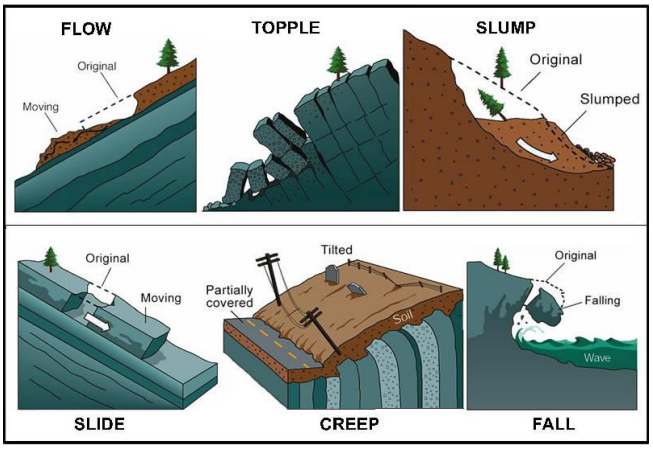

Figure 2: Classification of Landslide

C. Slide

Slide involves movement of material on a recognizable shear surface e.g. change of location and motion slide.

A landslide on that the surface of rupture is curved upward (spoon shaped) and also the slide movement is a lot of or less motion regarding associate an axis that is parallel to the contour of the slope. The displacement mass could, underneath sure circumstances, move as a comparatively coherent mass on the rupture surface with little internal deformation. The top of the displaced material could move nearly vertically downward, and also the side of the displaced material could tilt backwards towards the scarp. If the slide is motion and has many parallel curved planes of movement, it is known as a slump.

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- Down slope movement of a soil or mass occurring dominantly on surfaces of or on comparatively thin zones of intense shear strain.
- The sign of ground movement are cracks of the original ground.

D. Spread

- Sudden Movement on water bearing seams of sand or silt overlain by homogenised clays or loaded by fills
- May result from liquefaction or flow of soft material
- Mode of spreading :-block spreads, liquefaction, Rock spreading, soil spreading etc.

E. Flow

Flow may be a landslide during which the individual particles travel individually among a moving mass.
Spatially continuous movement, during which surfaces of the shear are short-lived, closely spaced and usually not preserved
On the basis of water content, mobility and evolution of movement, flows are differentiated from slides

Types of Movement		Types of Material		
		Bed Rock	Soil	
			Coarse	Fine
Falls		Rock fall	Debris fall	Earth fall
Topples		Rock topple	Debris topple	Earth Topple
Slides	Rotational	Rock slide	Debris Slide	Earth slide
	Translational			
Lateral spread		Rock spread	Debris spread	Earth spread
Flows		Rock flow (Deep creep)	Debris flow (soil creep)	Earth flow (soil creep)
Complex		Combination of two or more principal types of movement		

III. CAUSES OF LANDSLIDES

Many factors are contributing for landscape disaster such as geology, gravity, weather, groundwater, wave action, and human intervention. Landslide could occur on low relief areas in addition as on steep slopes. Landslides will occur as ground failure of river bluffs, cut and-fill failures that will accompany highway and building excavations, collapse of mine-waste piles, and slope failures related to quarries and open-pit mines. Underwater landslides sometimes involve areas of low relief and small slope gradients in lakes and reservoirs or in offshore marine settings. Mostly, one or additional factors triggers the landslide.

3.1 Natural Factors

1. Gravity: Steeper slopes are more vulnerable than gradual slopes.
2. Geological Factors: Numerous slides happen in a geologic setting that deposit permeable sands and rock above impermeable layer of residue and earth or bed rock. Seepage and accumulation of water from top to downward units affect the stability of the zone.
3. Earthquakes: Seismic activities have invariably been a main reason behind landslides throughout the globe. Any time morphology move the soil that covers moves with it. When earthquakes occur on areas with steep slopes, persistently the soil slips inflicting landslides. Furthermore, as the debris flows caused by earthquakes may also trigger mass movement of soil.
4. Heavy and prolonged rainfall
5. Water being one of the primary triggering factor affects the stability of inclines. Increase in water table or saturation in soil due to heavy or prolonged rain starts the run off which further affect the stability of slope.
6. Forest fire: Fires cause erosion and induce floods and landslides because of the destruction of the natural vegetation. (eg. ridges of Manipur-Nagaland border).

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7. Volcanoes: Seismic movements have been a fundamental driver of landslide. During the wet condition, strata may be prone to sudden collapse. The techtonic movement may trigger the landslide which results in slip of soil accelerating the large movement of soil on steep slop.
8. Waves: Wave action will erode the beach or the toe of a bluff, cutting into the slope, and setting the stage for future slides.

3.2 Human Intervention

Human actions most notably those who have an effect on drainage or groundwater, will trigger landslides e.g. inappropriate drainage system, amendment in slope/land use pattern, deforestation, agricultural practices on steep slopes, cutting & deep excavations on slopes for buildings, roads, canals & mining , inappropriate disposal of debris after excavations etc.

Change in slope/land use pattern, deforestation, agricultural practices on steep slopes:- Deforestation and cultivation of seasonal crops and increase in settlements. Improper land use practices likecultivation, agricultural practices and settlement patterns have contributed to creep and withdrawal of toe support in several cases.

3.3 Design of Drainage System

Natural drainage lines on slopes are blocked by terracing/ contour bounding adopted to stop erosion and to enhance percolation throughout time of year for cultivation, while not adequate provision for surface drainage of excess storm water during high intensity rains increase the landslide vulnerability.

3.4 Cutting & Deep Excavations on Slopes for Buildings, Roads, Canals & Mining

Developmental activities like construction of buildings, road cutting, embankments, cut and fill structures causes modification of natural slopes, interference of surface drainage, loading of critical slopes and withdrawal to toe support promoting vulnerability of vital slopes.

IV. LANDSLIDE CASUAL FACTOR

Landslide casual factors can be grouped for ease in documentation and planning on inclined sites.

Ground Conditions	Plasticity, sensitivity, weathering condition of material, sheared material, jointed or fissured material, adversely oriented mass discontinuities (including bedding, cleavage), adversely oriented structural discontinuities (Including faults, sedimentary contacts), Permiability and its effect on ground water
Geomorphological process	Techtonic uplift, Volacnic uplift, Glacial rebound, erosion of the slope toe, deposition loading of the slope or its crest, vegetation removal (by erosion, forest fire, drought)
Physical Processes	Intense, short period rainfall, rapid melts of deep snow, prolonged high precipitation,earthquake, volcanic rupture, shrink and swell weathering of expansive soils
Man madeprocesses	Excavation or loading on slope, drawdown, irrigation, defective drainage system, Deforestation, Mining and quarrying, artificial vibration

V. TRIGGERING FACTOR

Landslide disaster may be induced by natural or manmade causes. The three major triggering mechanisms for disaster that can occur either singly or in combinations are 1) Water 2) Seismic activity 3) Volcanic Activity. The factors such as steepness of slope, morphology or shape of terrain, soil type, underlying geology, population and typology of building.

5.1 Landslide and Water

Saturation of slope, because of intense rainfall, snowmelt, changes in ground water levels and surface water level changes along coastlines, earth dams, in the banks of rivers, canal, reservoirs, is a primary cause of landslide. Landslide

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may occur simultaneously with flood or landslide also cause flooding when sliding rocks and debris block stream channels and other water ways, allowing large volumes of water to back up behind such dams. Landslide also can cause tsunamis, overtopping of reservoirs and (or) reduced capacity of reservoirs to store water

5.2 Landslide and Seismic Activity

Earthquake in landslide prone areas increase the likelihood that landslides can occur due to ground shaking, liquefaction of susceptible sediments or shaking caused dilation of strata which allows rapid infiltration of water.

5.3 Landslide and Volcanic Activity

This is one of the most devastating types of failures. Many volcanic origin places experience periodic failure of their perimeter areas and masses of soil and rock slide into the ocean or other bodies. Such collapses may create massive sub-marine landslides , sometimes displacing the water, creating tsunamis that do damage at greater distance.

5.4 Human Activities

With increasing population and developing infrastructure accordingly, human activities contribute the occurrence of landslides. Disturbing or changing drainage pattern, land use pattern, destabilizing slope and deforestation are common human induced activities that may initiate landslides

VI. PREVENTIVE MEASURES

For adoption of mitigation strategies to the landslide hazard, a better understanding and characterization of landslide is very essential. The information on landslide along with climatic data from different regions are necessary to understand the influence of weathering, rainfall, or topography on landslide generation. This in itself is a reason to initiate landslide susceptibility mapping aimed at identifying potential areas at risk for this menace.

Social and economic losses due to landslides can be reduced by means of effective planning and management. Along with appropriate planning and designing, these approaches include:

- Development restrictions in landslide-prone areas,
- Implementation of excavation, grading, landscaping, and construction codes,
- Proper execution of physical measures (drainage, slope-geometry modification, and structures)

6.1 Mitigative Measures

Some of the mitigation strategies which can reduce the risk or losses because of landslide are mentioned below:

- Mapping and demarcating landslide prone areas along to help the future development activities
- Consideration of angle of repose to avoid steep slopes
- Backfilling with lightweight material
- Providing additional material at foot of the slope
- Reduction of loading such as debris, soil deposits or built structures on inclined areas
- Slope stabilisation using plantation
- Appropriate designing of retaining wall considering the load and slope
- Provision of well design drainage system to reduce the water content or pore pressure of the rock or soil
- Divert the surface runoff above the slope by use of impermeable material
- Strengthening of slopes
- By drilling horizontal boreholes to improve sub surface drainage
- Provision of lining to reduce the incidence and volumes of debris flows
- Soil reinforcement by geosynthtics
- Slope stabilisation by driving of vertical

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VII. CONCLUSION

In order to effectively manage landslide disasters, planners and responsible authorities must apply strict planning and design guidelines in landslide-prone and unstable locations. This requires taking lessons from past terrible incidents. A landslide can be caused by any one or a combination of the reasons outlined in the paper. Understanding the science of landslides, their causes, soil movement characteristics, the geology associated with them, mapping, vulnerability and risk evaluation and assessment, landslide disaster management can be effectively implemented by planning, designing, selecting the sustainable materials along with construction techniques, and actively involving all vendors in establishing the guidelines accordingly. In order to understand the mechanism of the landslide and the elements, it is crucial to determine the causes of landslides in a certain place.

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