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Study of Sustainable Techniques for Effective Risk Management and Control: A Review

Neha Thakur[1], Dr. Sakshi Sharma[2]
[1]Department of Applied Science, Chandigarh University Punjab
[2]Centers for International Projects Trust, New Delhi

Abstract: A geological disturbance is a broader term that refers to a variety of ground motions such as rock falls, slope failure, and shallow debris flows. The study of landslides has fetched a lot of interest recently, owing to a growing awareness of the socioeconomic consequences associated. The land in the mountainous region is especially susceptible to landslides due to its complicated geological context. Landslides are generally caused by the slope changing from a stable to an unstable condition, which can be caused by a variety of factors such as pore water pressure destabilising the slopes, loss or absence of vertical vegetative structure (after a wild fire or fire in forests lasting two or four days), erosion of toe of slopes by river, significant rain falls, earthquakes causing liquefaction of slope, blasting, earth work which alters the slope and imposes new load on it. If the slope is not stable and must support a large soil mass, the entire wedge may slide, resulting in the second type of landslide. Although climate change has also contributed to the occurrence of such disasters like landslides. As we all are aware about the relative causes of landslides, still it is a major concern for governmental organisations, authorities, geotechnical engineers and sub-urban planners for both public and structural safety. Landslides are a major issue in hilly areas especially in Himalayan region of India, where populace is more dependent on native resources and are prone to landslides too.

Keywords: landslide, landslide susceptibility, Liquefaction, Mitigation Techniques, Rock slope stability, Prediction of rock failure, Risk Assessment

I. INTRODUCTION

Landslides which are causing the direct and indirect damages more than $4 billion in the world, whereas Japan is way ahead if compared with countries in terms of destruction and on the scale of damage caused by landslides **{1,2}**. Landslides are also widespread in underdeveloped countries, with economic damages that are occasionally equal or exceed their gross national products **{2,3}**. Landslides threaten around 0.42 million sq km (12.6 percent) of India's geological area, excluding snow-covered areas. Approximately, 0.18 million square kilometres are in the North East Himalaya, which includes Darjeeling and Sikkim; 0.14 million square kilometres are in the North West Himalaya and around 0.08 million square kilometres are in the Western Ghats. The topography and potential seismic zones (Zones IV and V) of Himalayan region are the reasons for contributing more vulnerability to landslides**{4}.**Landslides are more likely to occur in geodynamic sensitive belts, which are certain zones and specific locations that are mostly affected by tremors and other seismic activities on smaller scale **{5,6}**. The Darjeeling in Himalayas, for instance, has had over 20,000 landslides in a single day, making it the Himalayan range's most vulnerable zone. Nearly 30,000 people died as a result of it in 1968. The most recent calamity occurred in Uttarakhand and the causal impacts studied claimed climate change as one of its key reason. In June 2013, a multi-day cloud burst concentrated on Uttarakhand, India's northernmost state, triggered disastrous floods and landslides, making it the country's highly affected natural disaster since the occurrence of tsunami of 2004. The debris from the construction of dams in the upstream region contributed to the floods being on a far larger scale than the state's typical floods. The debris clogged the rivers, resulting in significant flooding. The primary day of the flood, according to reports, was June 16, 2013. Despite the fact that the flood affected varied regions of India which were Himachal Pradesh, Haryana, Delhi, and Uttar Pradesh, as well as some parts of Western Nepal and Western Tibet, but over 89 percent of the deaths happened in Uttarakhand region only. According to estimates released by the Uttarakhand government, more over 5,700 individuals were "presumed dead" as of July 16, 2013 and around 934 reported dead were natives of this region only.

Due to the spurring urban settlements and inexorable industrial and developmental activities are responsible to cause the ecological imbalances in the prevailing environmental conditions and if these distressing environmental situations are dealt with unresponsive behaviour than the further type, recurrence and extent of disasters will be beyond calculative scales.

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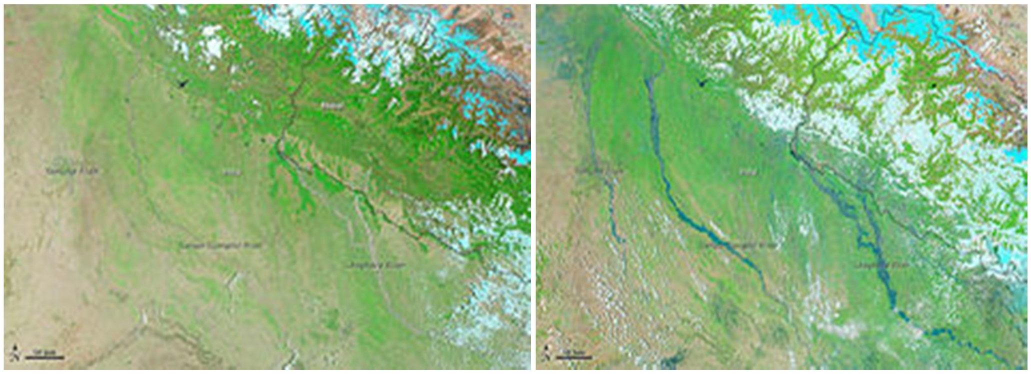


(a): Image taken on 30 May 2013 (b) Image taken on 21 June 2013

Figure 1: Satellite image of the flood affected region by NASA's MODIS

It is practically impossible to avoid landslides, the task before urban planners, geotechnical engineers is to identify landslide-prone locations and categorise them on a scale that allows for preparedness and mitigation.

II. LANDSLIDE CLASSIFICATION

The various principle types of landslides and their mitigation measures are listed below in the table **{5}.**

A. As per Indian Standard Landslide Control—Guidelines (1999)

Table 1 Landslide Classification System {5}

Type of Movement		Type of Material: Soils – Predominantly fine	Type of Material: Soils – Predominantly coarse	Type of Material: Bed Rock	Recommended Control Measures
Falls		Earth fall	Debris fall	Rock fall	Geotextile nailed on slope/spot bolting
Topples		Earth topple	Debris topple	Rock topple	Breast walls/soil nailing
Slides	Rotational	Earth slump	Debris slump	Rock slump	Alteration of slope profile and earth and rock fill buttress
	Translational	Earth block slide	Debris block slide	Rock block slide	Reinforced earth or rock reinforcement in rock slope
		Earth slide	Debris slide	Rock slide	Biotechnical measures
Lateral Spreads		Earth spread	Debris spread	Rock spread	Check dams along gully
Flows		Earth flow	Debris flow	Rock flow	Series of check dams
		(Soil creep)		(Deep creep)	Rows of deep piles
Complex		Combination of two or more principal types of movement			Combined system

III. FACTORS GOVERNING THE OCCURRENCE OF LANDSLIDES

Heavy and prolonged rainfall, cutting and deep excavations on slope for construction of buildings, roads, canals, and mining without proper waste disposal, and seismic shocks and tremors are the main elements that initiate or trigger mass movements. Landslides may occur in developed and undeveloped regions depending on terrain characteristics which have been altered due to varied ongoing or relentlessly completed urban developmental activities in that particular area. The Himalayan region is the most seismically active part of the Indian subcontinent, with earthquakes of significant magnitude shaking its north-eastern and north-western ends on a regular basis. The amount of rainfall in the outer ranges is in excess of 200 cm/yr. People have been compelled to move up the higher forested slopes with their ploughs and animals due to widespread deforestation for development activities and increasing population pressure**{8}.** It exacerbates the risk of landslides in terrain with varied relief.

The central governing force responsible for landslides is gravitational force and resistive force which resists the movement of soil mass is directly proportional angle of internal friction of the material and inversely proportional angle of hill. Furthermore, in the event of extended rains or earthquake vibrations, the resistive forces can be greatly reduced. The rate at which various types of landslides occur varies significantly. Landslide Susceptibility Zonation (LSZ) is based on a comprehensive understanding of slope motions and the parameters that affect them. The amount and quality of accessible data, the working scale, and the choice of appropriate analytic and modelling methods all have a role in the credibility of landslide susceptibility maps **{6,9-12,13}**. As per Terzaghi (1950), "If a slope has started to move, the means for preventing movement must be matched to the processes that caused the slide,". Other variables that contribute to landslides include the use of cut-and-fill slopes that are not subjected to geotechnical study and calculations. Cut slopes are quite common in cut slopes (1V:1H). The effective angle of friction of residual dirt, on the other hand, varies from 290 to 360 degrees, depending on the particle size distribution of the soil particles. In other words, without thorough geotechnical analysis and design, engineers should just follow the slope gradients (e.g. 1V:1H) that have been done previously**{14}**.

IV. CLIMATE CHANGE AND LANDSLIDE INITIATION

Slope stability can be affected significantly by long-term climatic change**{15}**. Rainfall has an impact on natural slopes, and unstable slopes will fail. Disintegration of rocks and climate change caused by natural and human activities control the occurrence of fresh landslides. Climate change, on the other hand, has an impact on rainfall and snowmelt patterns in many areas. Rainfall that is heavier and lasts longer may result in fresh landslides. Climate change and variability should be considered in landslide study and prevention, in the study for the preventions of land slide occurrence in the prone areas.**{16}.**

Table 2: Top Seven Countries affected by landslides

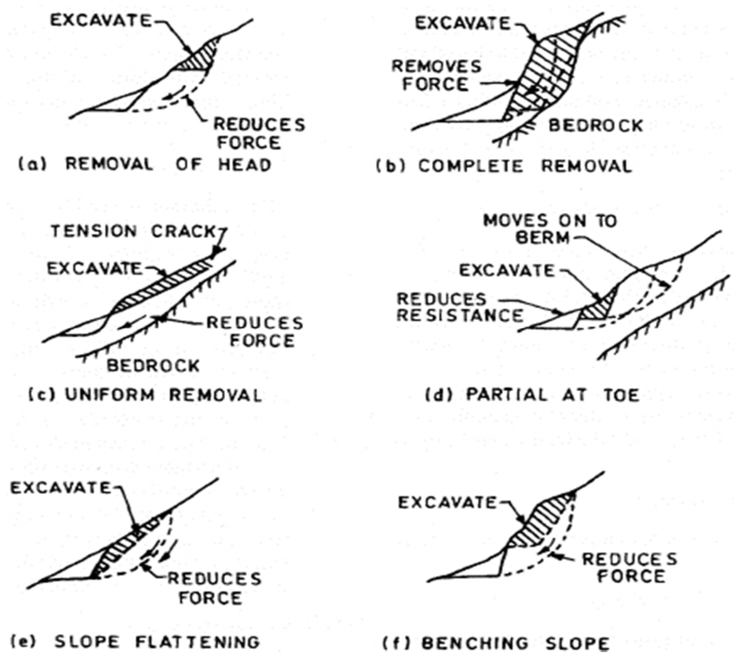
Country	Date	Killed
Brazil	11 Jan 1966	4,000,000
India	Jul 1986	2,500,000
India	12 Sep 1995	1,100,000
Afghanistan	13 Jan 2006	300,000
Nepal	15 Jul 2002	265,865
Indonesia	31 March 2003	229,548
Philippines	19 Dec 2003	217,988
India	17 Aug 1998	200,000
Bolivia	Feb 1994	165,000
Brazil	30 Jul 2000	143,000

(From: Centre for Research on the Epidemology of Disasters,CRED,EM-DAT)

Upgrading man-made slopes may need a combination of different sorts of labour. As a result of technological improvements in slope engineering and building techniques, the design and construction practices for man-made slopes have evolved over time. **{17}.**

V. MITIGATION STRATEGIES BY OPTIMIZING TECHNICAL ADVANCEMENTS

Direct and Indirect approaches of landslide mitigation are split into two categories. Direct methods include techniques like retaining walls, anchoring walls, restraining piles, and other restraining structures, as well as alleviating pressure through excavation and slope restoration utilising reinforced earth and rock reinforcement. Erosion control strategies, as well as improvements in surface and sub-surface drainage, are examples of techniques in Indirect methods. **{7}.**



VI. DIRECT APPROACH FOR MITIGATION OF LANDSLIDES

A. Gabions/Sausage Walls

Gabions were modified and patented by Gaetano Maccaferri in the late 1800s in Sacerno, Emilia Romagna, for use in civil engineering to reinforce shorelines, stream banks, and slopes against erosion. A gabion wall is a type of retaining wall made up of piled stone-filled gabions that are connected by wire. Rather than being built vertically, gabion walls are battered (angled back towards the slope) or stepped back with the slope. They are occasionally used to keep falling stones from a cut or a cliff from putting people's lives in danger. Gabions perform effectively in unimproved channels because their surface roughness is more in line with that of natural channels. When undercut by the stream, gabions can also absorb considerable deflections**{18}**.

B. Stability Using Soil Cut Slopes

In ancient time, the most common way to improve the slope stability was to cut it the hill slope with the gentle slope (Koirala and Tang, 1988) **{17,19}.**Up to the angle value of 30-35 degree the slope material is stable and slope should be cut below the angle value of 30 degree.However, the angle at which landslides are most likely to occur is 26°**{21,22}.**

Hand dug caissons and retaining walls which are structural supports can be employed to increase the slope stability at the crest to accommodate the cut back profile wherever the sufficient space is not available. **{17,20,23}.**

C. Re-compaction of Fill Slopes

Economically viable, re-compacted buttress fills were the primary option for restoring landslides during the 1950s and 1960s **{18}**.When substandard fill slopes, often made up of loose fill materials, become wet and are sheared, they are prone to liquefaction. Hill slopes can be stabilised by compacting upper 3m of layer to achieve the maximum relative density and it was the most traditional way for handling the hill slopes. In rare circumstances, rock fill or soil stabilised by mixing cement has been used instead of compacted soil fill to compact the upper 3m layer of the soil{**17,24}.**

D. Restraining Structures

Slope stability difficulties (height 4 m) are usually controlled by restraining structures. Where space is limited, appropriately designed and constructed rigid restraining structures are appropriate. Random rubble dry stone masonry is used to build retaining walls up to 3 metres high. Lime/cement mortar masonry bands are used to construct retaining walls over 3 metres in height **{7}**.

E. Concrete Retaining Walls

Gravity walls made of concrete are quite expensive, yet they are useful for major structures and sites. Such barriers must be built on bedrock{7}. The weep holes in the retaining structure will avoid the water retention and to release the excess hydrostatic pressure within the soil mass. The drain (weep) holes in the retaining wall prevent water retention and hydrostatic pressure build-up behind the wall**{21,26}**. To resist the lateral thrust, the safety factor can be used to find the amount of resistance **{7}**.

F. Anchored Walls

The maximum height of a free-standing gravity wall is around 10 metres. Soil slopes are typically stabilised by deep, prestressed anchors. Prestressed anchors and gravity structures have a significant advantage over unstressed anchors and gravity structures in actively fighting the movement of the soil mass**{7}**.

G. Restraining Piles

To avoid the small scale landslides the piles are inserted in the weak soil mass through the bore holes. Steel or reinforced concrete piles must be used for them. Because the pile's length is longer than its diameter, it's classified as a bending pile.**{7}.**

H. Restraining Structures Using Empty Bitumen Drum

Nominal reinforing materials are used to build the temporary low cost restraining structures. The bitumen drum's top and bottom covers are removed, and the cylindrical shell is used instead. Two rows of these are stacked one on top of the other. Mild steel plates, rods, and bolts join the drums both vertically and horizontally (see Fig. 4). To prevent sliding and tilting, the drum wall is properly fastened at the base as well as to the back fill. The trash and rocks are then added to the drums to provide weight and stability**{7}**.

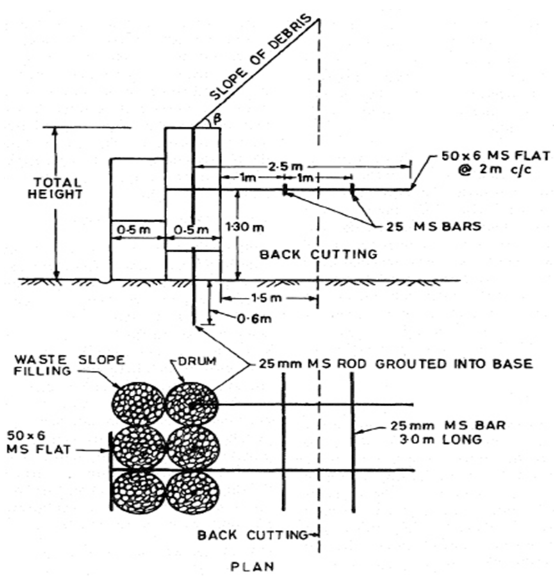


Fig. 4 Anchored Drum Diaphragm Wall Built of Slope Waste and Empty Bitumen Drum

I. Reconstruction of Slope Using Reinforced Earth

Using Soil Nailing and Grillage Construction

Soil nailing is a different way to upgrade loose fill slopes. It's a method (BS 8006-2, 2001) for increasing the slope angle of a designed slope artificially. During the construction procedure, existing trees might be retained. To achieve adequate anchorage against pull-out, the soil nails are inserted in competent subsurface strata.Because of the building advantages given by soil nailing, the technology is increasingly widely utilised for fill slope upgrades**{17,27}**

J. Flexible Steel Ring Type Debris-resisting Barriers

Loose rocks can be fastened to the slope with wire mesh to prevent them from rolling down. The net is powerful enough to stop rocks with a diameter of up to 1m**{21,28}**.Steel ring nets are woven between horizontal steel ropes stretching between steel posts and fixed into the ground to create flexible barriers. The energy technique is used to construct flexible rock fall barriers, in which a falling rock or boulder is stopped in one piece by a barrier designed to absorb the kinetic energy carried by the rock or boulder

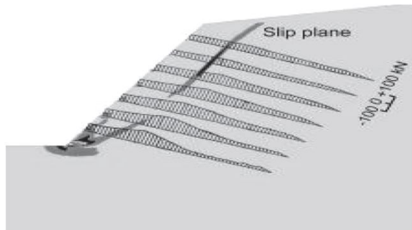


Fig. 5 Soil Nailing

Fig.6:Flexible barrier at the toe of a natural hillside.

K. Using High Stiffness Geocomposite Mesh System

Wire mesh, held in place by a system of anchors and ropes, is one of the most typical solutions for susceptible soils and rock slopes. A variety of meshes are offered from various producers all around the world. For nearly 60 years, hexagonal 'double twist' type meshes have been utilised successfully in civil and geotechnical engineering projects**{7}.**

L. Indirect Approach for Mitigation of Landslides

1) *Hydroseeding:* Hydroseeding which is also called as hydraulic mulch seeding, hydro mulching or hydraseeding used as soil erosion technique in construction sites where a slurry of seed and mulch is prepared for plantation{21,30,31}.For plantation in large area, Hydroseeding process can be used because it takes very less time. It can be highly useful for erosion management and rapid planting on hillsides and sloping lawns. Slope instability is exacerbated by the removal of natural vegetation from slopes, as previously stated {2,21}.
2) *Surface Drainage:* Surface water management is divided into two parts: i)In an unstable area, to hold the runoff water at the uphill boundary; and (ii)In an unstable area, to hold the runoff water at the downhill boundary or Increasing the amount of run-off. Catch water or interceptor drains, side drains, and cross-drains these are most common type of drainage system which is being utilised**{5}** To ensure quick flow away from the unstable area, the ditch gradient should be at least 2%**{32}.**
3) *Sub-Surface Drainage:* Due to its successful stabilisation method, drainage surface water and ground water used very extensively but its cost is high as compared to its stabilising efficiency **{2,33}**.

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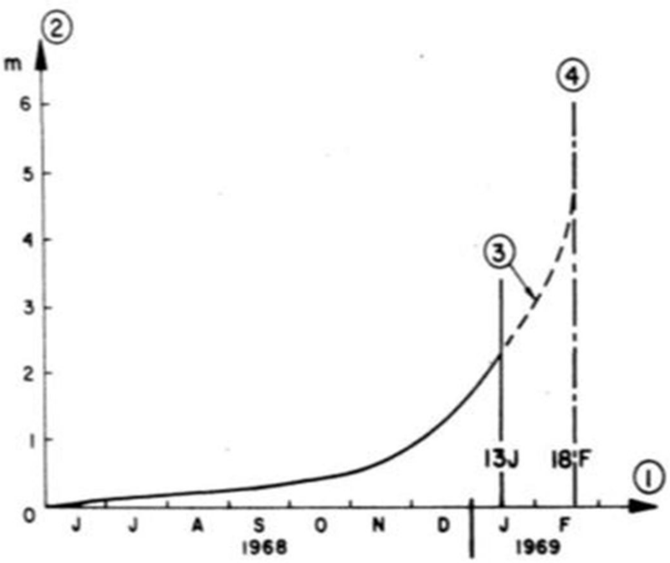
Other options include backfilling with lightweight material (such as woodchips or logging slash) and then covering the backfilled material with a thin layer of coarse aggregate to create a foundation for limited-use traffic. Crib walls are another form of mitigation measure that works well when the amount of soil that needs to be stabilised is limited. Timber crib walls are interconnecting log box structures that are backfilled with coarse aggregate. Surface reinforcing between blocks of rock is provided by shotcrete and guniting, which also helps to decrease weathering and surface scaling. **{32}**.Chemical treatment, freezing, thermal treatment, and grouting are some of the soil hardening treatments. **{15}**.The Stability Margin, risk, uncertainty, possible consequences, constructability, environmental implications, short- and long-term performance, and costs should all be considered when choosing a mitigation system**{34}.**

VII. PREDICTION OF SLOPE FAILURE

Under the unavoidable circumstances, slope cannot be maintained. In such conditions men, power and equipment's cannot be delivered before the slope fails due to that the failure of slope cannot be identified.

The best example of slope failure prediction at Chuquicamata mine in Chile(Kennedy &Niermayer, 1970) Authors predicts the slope failure between a plot of surface displacement vstime{**35**}.



1) Date.
2) Displacement in meters.
3) Extrapolation of data collected up to 13th January 1969.
4) Predicted failure date.

Fig. 7: Plot of displacement of fastest moving target on the face of the Chuquicamata mine (Chile). The failure, involving approximately 12 million tons of material, occurred on 18th February 1969. **{35}**

At Mansa Devi (Haridwar) landslide site where neuro-fizzy technique used by S K Mittal*, Sunil Dhingra, and H K Sardana to capture data from an instrumentation network (rain gauge, inclinometer, tiltmeter, crack metre, and earth pressure cell). To monitor landslide risk and to collect the realtime information of landslide by using alarm signal and GSM Technology to researchers, emergency personnel, and others assisting in assessing developing dangers, neuro-fuzzy systems are being utilized in places of high landslide risk, where dangerous circumstances can develop quickly **{36}.**For risk assessment research, new techniques such as DInSAR and high resolution image processing are increasingly being used. DInSAR is a strong technology for measuring displacements from satellites that has been used to detect subsidence, landslides, earthquakes, and volcanic activity. LISA (Linear SAR), a ground-based radar device, is capable of analysing the deformation field of an unstable slope in locations with high radar reflectivity **{37}**.

VIII. GSI'S ACHIEVEMENTS IN LANDSLIDE STUDY

Through macro scale landslide susceptibility mapping, the GSI (Geological Survey of India) has covered a large portion of India's accessible vulnerable hilly terrain. Until 2013, landslide susceptibility mapping on a 1:50,000 scale had covered more than 50,000 km2 of land. GSI conducted research and collaborated with national and international institutes to create terrain-specific landslide mapping methodologies. GSI conducts site-specific landslide investigations at the request of road maintenance authorities and provides input into the formulation of both immediate and long-term mitigation strategies. In order to provide the correct output in NLSM, data integration and susceptibility modelling must be done in GIS using acceptable procedures.**{1}**

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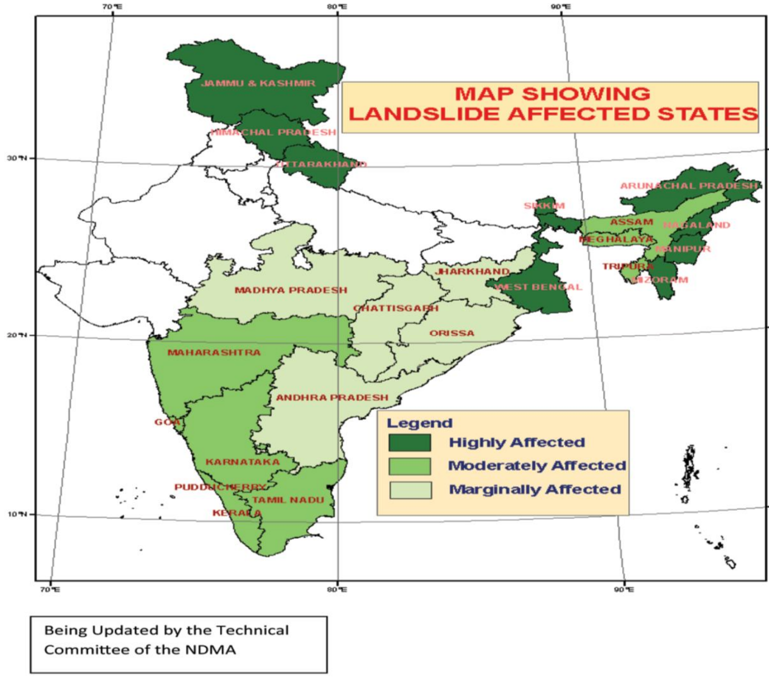


Fig.8 Landslide affected States (Source:National Disaster Management Guidelines,Government of India)

IX. LANDSLIDES AND RISKS ASSESSMENT

Landslides and the concept of risk are intertwined. The uncertainty of a landslide occurring at any moment or in any location, as well as the potential for damage and lives, is a constant source of stress. As a result, it poses a threat to both people and infrastructure. This gives the meaning of landslides a socioeconomic dimension **{21,39}**.

There are different ways to minimise the landslides by using education and forecasting stabilisation, prediction and protection. It can also be reduced by seeking the help of government bodies.**{21}**. Risk analysis is divided into three areas by Field & Field (2002). i) Risk assessment ii) Risk valuation, and iii) Risk management. **{21,41}**.To reduce the landslides proper understanding of nature of upcoming possible danger should be there. Examples of prior landslides are useful in determining why they happened, how often they happened, how much damage they did, and how they may have been avoided. The knowledge can then be used to help prevent future landslides**{21,40}.** It is possible to evaluate if a house or a road should be built on a certain site by conducting study. Risk assessment is carried out by compiling data from monitoring, forecasting, and prediction into a hazard map document. Digital elevation model (DEM), which is commonly used to derive features of topography such as slope inclination, slope aspect, slope curvature, and drainage, is employed in GIS-based techniques. **{37}**.

"Only stabilisation aims to mitigate one or more primary failure modes while also improving slope stability." The latter three options (protection, avoidance, and maintenance and monitoring) allow for slope failure while attempting to avoid, mitigate, or mitigate the consequences. A "do-nothing" alternative is a management approach/decision, not a mitigation strategy; a "do-nothing" alternative is a management approach/decision, not a mitigation strategy."**{42.}**

X. CONCLUSION

Every country with mountainous topography has landslide-prone zones, and numerous landslides may occur in a year, but the important issue is that only those landslides that wreak devastation be taken into account. Forecasting and mitigation strategies play a critical role in lowering the landslide risk value. The most imperative factor is to forecasting, implement and act as per the suggested safety procedures based on historical data that should be adopted prior to the occurrence of landslides in order to reduce the impact of risk. The financial costs associated with risk management that occur for that area, as well as risk perception, often influence the choice of landslide mitigation approach. Initiatives to increase the populace awareness of the hazard and its management would make people better aware of the risks that they face, especially those that live in high risk areas. Providing incentives to encourage individuals for opting better resilient structures is feasible solution for governing authorities to reduce the impact of any calamity in any risk prone region.

REFERENCES

[1] "Socioeconomic Significance of Landslides," Chapter 2 in Landslides – Investigation and Mitigation, Special Report 247, Schuster, R.L.(1996),Transportation ResearchBoard, National Research Council, Turner, A.K. and Schuster,R.L., Editors, National Academy Press, Washington, D.C

[2] Engineering Measures for Landslide Disaster Mitigation,Mihail E. Popescu (Illinois Institute of Technology, USA), KatsuoSasahara (Kochi University, Japan).

[3] Editors (2005) Landslides: Risk Analysis and Sustainable Disaster Management, Springer,Sassa, K., Fukuoka H., Wang F.W., Gonghui Wang.

[4] Mapping of landslide zones, Geological Survey of India, link http://www.gsi.gov.in

[5] Landslide Hazard, Geological Hazard, Springer Verlog, New York, Bolt, B.A., (1975)

[6] Landslide Hazard and its Mpping usingRemote Sensing and GIS,Journal of Scientific Research, Vol. 58, 2014 : 1-13,Praveen Kumar Rai, Kshitij Mohan and V.K.Kumra.

[7] Indian Standard Landslide Control—Guidelines © BIS 1999 Bureau of Indian Standards

[8] A Geographical study of landslides perspective in geormorphology,edit. by Sharma H.S., Concept, New Delhi, 283-294. Saxena, P.B., 1981.

[9] Landslide hazard assessment: summary review and new perspectives,Bulletin of Engineering Geology and the Environment, 58 (1) 21–44, Aleotti, P. and Chowdhury, R., 1999.

[10] Landslide Susceptibility Mapping in a Part ofUttarkashi District (India) by Multiple Linear Regression Method, International Journal of Geology, Earth and Environmental Sciences, Vol-2 (2), pp 102-120, Onagh, M., Kumra, V.K., Rai P.K. 2012.

[11] Slope instability recognition, analysis, andzonation, In: Turner, K.A., Schuster, R.L. (Eds.), Landslides: investigation and mitigation, Transport Research Board Special Report, 247, 129– 177, Soeters, R., Van Westen, C.J., 1996.

[12] Landslide hazard evaluation: a review of current techniques and their application in a multi-scale studyCentral Italy,Geomorphology, 31(1-4), 181–216, Guzzetti, F., Carrara, A., Cardinalli, M., Reichenbach, P., 1999

[13] Mechanisms of Landslides" ,GeologicalSociety of America, Berkley, 83-123Terzaghi, K. (1950).

[14] Landslides: Case Histories, Lessons Learned and Mitigation Measures,Ir. Dr.Gue See-Sew &Ir.Tan Yean-Chin.

[15] Landslide Loss Reduction:A Guide for State and LocalGovernment Planning: Robert L. Wold, Jr.Colorado Division of Disaster Emergency Services and Candace L. Jochim ,Colorado Geological Survey.

[16] Report of ICSU ROAP Planning Group on Natural and Human Induced Environmental Hazards and Disasters, Science Plan on Hazards &Disasters, ICSU(International Council For Science).

[17] Landslide disaster prevention and mitigation through works in Hong Kong,Journal of Rock Mechanics and Geotechnical Engineering 5 (2013) 354–365, K.Y. Choi*, Raymond W.M. Cheung

[18] Overview of Landslide Mitigation Techniques For Slope Stability & Landslides Course, University of Wisconsin-Madison,Engineering Professional Development,J. David Rogers,2014

[19] Design of landslip preventive works for cut slopes in Hong Kong.In: Proceedings of the fifth international symposium on landslides.Lausanne,Switzerland: A.A. Balkema; 1988. p. 933–8. Koirala NP, Tang KY

[20] The use of large diameter piles in landslip pre-vention in Hong Kong. In: Proceedings of the tenth Southeast Asian geotechnicalconference; 1990. p. 197–202. Powell GE, Tang KW, Au-Yeung YS..

[21] Landslides in Hong KongJuhaniAleksi HORELLI ,University of Helsinki ,Faculty of Agriculture and Forestry ,Department of Economics and Management.

[22] Landslides, Slope Failure, and Other Mass Wasting Processes',Watkins, Anni& Scott Hughes, 2004.

[23] The reliability of the design of cuttings in Hong Kong (GCO Discussion Note 5/85), In: Hong Kong: Geotechnical Engineering Office, HKSAR Govern-ment; 1985 ,Malone AW.

[24] Report on the slope failures at Sau Mau Ping. Hong Kong: Government of HongKong; 1977. HKG.

[25] @ 'Measures for Control and Management of Unstable Terrain',Chatwin, S.C. 1994,Ministry of Forests, Canada.

[26] Retaining Walls', Wilson, Thomas H. 2004.

[27] Soil nails in loose fill slopes (a preliminary study) – final report. Hong Kong: Geotechnical Division, The Hong Kong Institution of Engineers; 2003. HKIE.

[28] Rockfall Protection: Challenges in Design and Installation', Erosion ControlO'Malley, Penelope, 2000.

[29] Suggestions on design approaches for flexible debris-resisting barriers (GEO Discussion Note 1/2012). In: Hong Kong: Geotechnical Engineering Office, HKSAR Government; 2012. Kwan JSH, Cheung RWM.

[30] 'Erosion Control: Planning, Forest Road Deactivation and HillslopeRevegetation', Ministry of Forests, Canada, Schwab, J.W. 1994.

[31] GEO Report no. 75: Landslides and Boulder Falls From Natural Terrain: Interim Risk Guidelines, Hong Kong: Civil Engineering Department, ERM,1998

[32] Introduction to Landslide Stabilization and Mitigation, Appendix C-The Landslide Handbook—A Guide to Understanding Landslides.

[33] "The Stability of Slopes."Blackie Academic & Professional, London, Bromhead, E.N. (1992).

[34] Landslide Mitigation Engineering Geology and Geotechnical Engineering Symposium, Logan UT,George Machan, PE, Landslide Technology, Portland, Oregon

[35] General report for third congress of the international society for rock mechanics,E. Hoek, Professor of Rock Mechanics, Imperial College, London P. Londe, Technical Director, Coyne &Bellier, Paris

[36] Analysis of data using neuro-fuzzy approach recorded by instrumentation network installed at Mansa Devi (Haridwar) landslide site,S K Mittal[1]*, Sunil Dhingra[2] and H K Sardana[1],[1]Central Scientific Instruments Organization (CSIO, CSIR),[2]Institute of Instrumentation Engineering (USIC), India.

[37] Strategies for mitigation of risk associated with landslides, p-6,9.Farrokh Nadim[1] & Suzanne Lacasse[2],Director, International Centre for Geohazards / NGI, Oslo, Norway[1], Managing Director, Norwegian Geotechnical Institute / ICG, Oslo, Norway.[2]

[38] National Disaster Management Guidelines,Government of India, Management of Landslides and Snow Avalanches.

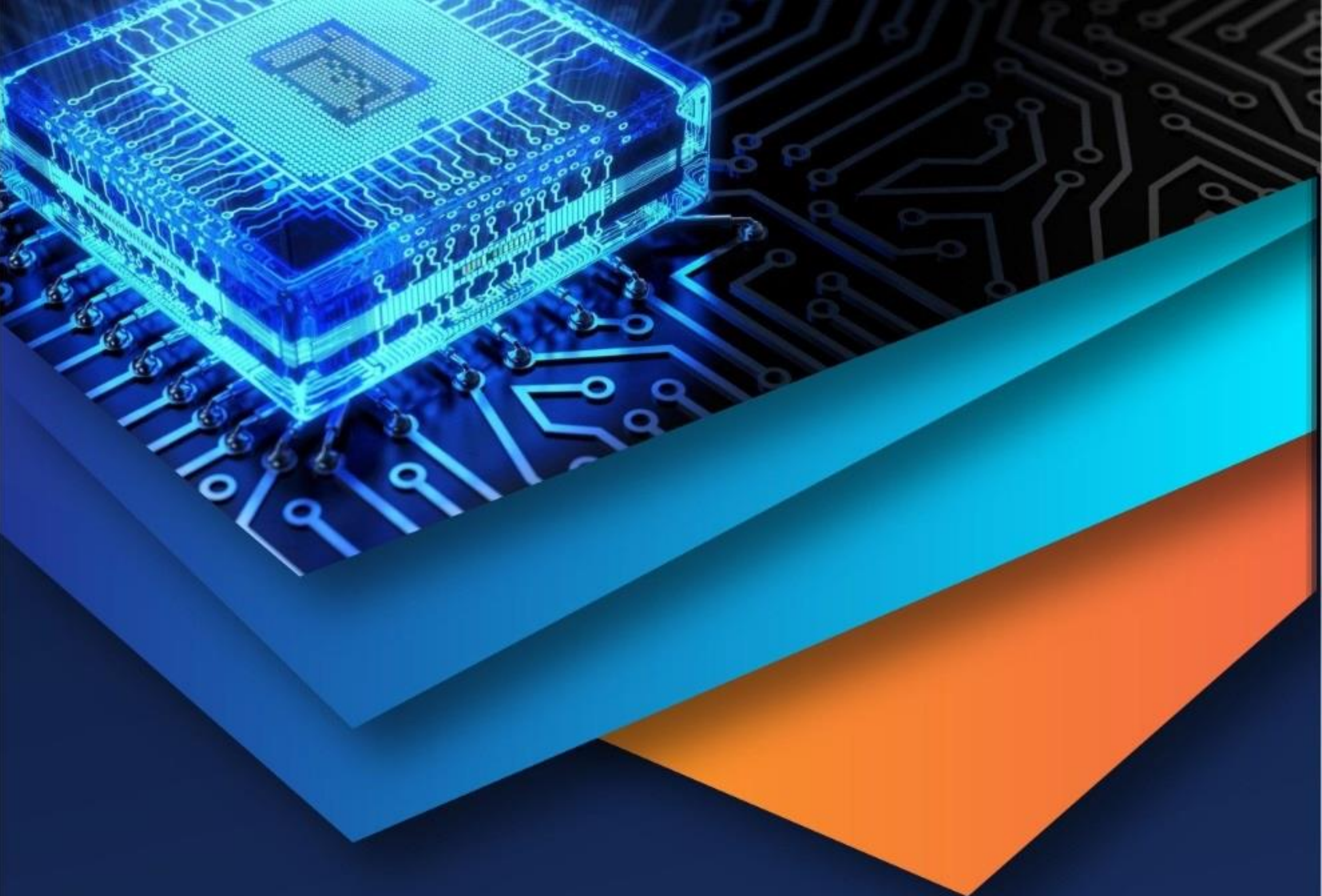
[39] EnvironmentalGeology – Geology and the Human Environment, Bennett, Matthew R. & Peter Doyle, 1997, Chichester: John Wiley & Sons Ltd.

[40] 'Reducing Vulnerability to Natural Hazards: Lessons Learned from Hurricane Mitch: A Strategy Paper on Environmental Management', Uribe, Alberto, Shigeo Sakai, Javier Cuervo, Henrik Franklin, Pascal Girot, Sergio ,Mora-Castro, Luis Ferraté, Isaac Ferez, Caroline Clark & Stephen Bender. 1999.

[41] Environmental Economics: An Introduction,Field, Barry C. & Martha K. Field. 2002,New York: McGraw-hill/Irwin.

[42] Landslide Mitigation Action Plan,Washington State Department of Transportation (WSDOT)Rail Division, David Smelser.

[43] Rock and soil slope protection using high stiffness geocomposite mesh systemD.CheerMeccaferriS.p.a , Italy, G. GiacchettiAlpigeo, Italy



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