Analysis of Landslide Hazard Zones Using GIS and Remote Sensing in Western Ghat Maharashtra (Chandoli Region): Review Paper

[1]Mr. Vaibhav Bhagwan Kashyap, [2]Prof. Shrikant M Bhosale, [3]Dr. Jalandar D Patil.

[1]P.G.Scholar, [2]Prof, Co-ordinator, [3]Research Professor
[1]Environmental Science and Technology,
[1]Department of Technology, Shivaji University. Kolhapur, Maharashtra. India.

***Abstract*: Landslides are one of the most dangerous natural disasters in mountainous areas. The area around Chandoli affected by landslides is selected for the study purpose. These area falls into four districts of Maharashtra namely - Satara, Sangli, Kolhapur and Ratnagiri. Landsat8, Google Earth, Google Maps, and other satellite images, as well as Survey of India (SOI) topographical sheets, serve as the foundation for obtaining baseline information on different metrics such as NDVI slope, relative relief, drainage density, and geology/lithology. The purpose of this research is to understand the importance of mapping geological ligaments and landscape characteristics including streams, slope, and aspect. Rainfall is one of the primary causes of landslides. Any corrective action must include one or both of the following characteristics. Thus, landslide hotspots will be identified using GIS and remote sensing. The pictures for the analysis were collected in FEBRUARY 2022, and the analysis will be completed in the months of May and June.**

Index Terms: Landslide, GIS, Remote Sensing, Mapping, Survey of India etc.

I. Introduction

A landslide, also known as a landslip or mudslide, is a type of mass wasting that involves a variety of ground motions such as rock falls, deep slope collapse, and shallow debris flows. Landslides are a major concern in virtually every area of the world because they create economic or social damages on private and public property. Natural calamities have shown the devastating potential of rapid mass movements during a landslide, which cost lives and inflict significant damage to property and infrastructure on an annual basis. Remote Sensing (RS) and Geographic Information Systems (GIS) play critical roles in the effective mitigation and management of disasters, providing a framework for monitoring, evaluation, detecting deficiencies, and suggesting suitable disaster management methods. RS and GIS have become important tools in geology for predicting and estimating natural hazards. GIS may be used to build hazard analysis models that can be utilized to save lives and property, ranging from better monitoring of prospective crises to better monitoring of potential disasters. Although natural disasters have increased dramatically and frequently over the past few decades, there has been a tremendous increase in the power of technology to mitigate them. As a result, the economic damage caused by natural disasters is growing with time. These human settlement disturbances, new urbanism, and engineering contractions consume a portion of the natural budget. Hazard assessment is required to identify any examined area with a degree of hazard, which may then be used for land-use planning. Chandoli region in Maharashtra is divided by arid climate, low population density, natural vegetation, low soil conditions, diverse geomorphology and slope gradient. Any sustainable development strategy in the Chandoli region (western ghat) faces significant environmental challenges like as landslides, shortage of water supplies, flash floods, and groundwater contamination. Furthermore, hazardous behaviors brought about by the quick rate of development may endanger the area's natural and cultural assets indefinitely. Chandoli and its surrounding area have been selected as a pilot study on district natural hazards and planning for the entire Western Ghat region. Landslide risks represent a serious threat to life, property, and infrastructure, and can constitute a major impediment to the area's growth.

II. Study Area

One of Chandoli's most significant drainage basins is under examination. The tested area covers the Chandoli region including Tiger Reserve and National Park and is located in India at 17 04' 00" N to 17 19' 54" N and 73 40' 43" E to 73 53' 09" E. Remotely gathered data will be produced from LandSAT8-9, IRS-P6, LISS-III (2005, for ref.) The subsidiary data will be digitally treated and collateral data will be generated from topographic maps. Subsidiary data will be managed digitally and collateral data will be created on topographic maps. Limited landscape and metaphor estimates for 1977 and 2005 disclosed that 120.9 km2 of conifer forest which existed for 28 years, has now disappeared. On contrary to this, there is an increase of 51.15 km2 in shrubs and 64.19 km2 in grasslands. In addition, forest cover and land use maps of the study region will be included from subsidiary data utilizing 'direct maximum likelihood categorization method'. This study will help demonstrate that the Study Area supports a variety of shrub habitats, grasslands, reclaimed land, and conifers. The study will be used to make Analysis of Landslide Hotspots in Western Ghat (Chandoli region, Maharashtra) Using GIS & Remote Sensing along with its environmental impact on the concerned region. Since the Sahyadri range is in the middle of the study area and receives heavy rainfall, soil erosion is likely in the area.

III. Literature Review

This section discusses key findings from the available literature on landslide hazard, the use of GIS in landslide zoning and mapping, and remote sensing. and mitigation planning for landslide prone areas. Landslide and related literature published in various

magazines, books and websites. This literature takes into account previous research, literature, study studies from different parts of the world. This literature is analyzed under two themes.
1. Landslide
2. GIS and remote sensing susceptibility mapping.

Literature Study

Landslides

[1] Wei zuoan.et al., 2006. A dynamic comprehensive technique for land- slide control" was the topic of this study. Due to increasing external stresses and deterioration of slope geo materials, a slope failure develops, resulting in a progressive and dynamic development and occurrence of landslides. Because the geological features of the site, as well as other active elements like hydro-dynamic stress and human activities, are complicated and often unknown, the dynamic evolution and occurrence of landslides can only be understood through the collection of information about landslides. This research provides a dynamic comprehensive control approach for landslide control for such a progressive process. This control technique stresses the deployment of viable landslide control measures at appropriate stages and in diverse groups, and takes full advantage of updated monitoring data and landslide site investigations. These precautions are being taken to avoid a landslide calamity

[2] Ancuúta rotaru et al., 2007. Understanding the reasons of slope growth, particularly the commencement of movement, necessitate knowledge of a number of parameters, most of which are connected with groundwater and are typically difficult to establish. Heavy rain, rapid snowmelt, a wet winter and spring, particularly if previous years were also wet, the removal of material from the base, loads of material at the top, earthquakes, erosion, poor forest management, the addition of water to a slope from irrigation, roof downspouts, poor drainage, septic-tank effluent, canal leakage, or bro- ken water are all common causes of landslides. The majority of landslides in Romania are caused by a combination of inadequate forest management and heavy rainfall. In recent years, structural geology has been employed to study the emergence and evolution of possible rockslides. Recognizing the factors that produced the movement is critical to comprehending the avalanche mechanisms. This study examines the movement of landslides from the perspective of many stages of landslide activity, including pre-failure, failure, post-failure, and reactivation.

[3] Ulrich Kamp et al., 2008. The Mw7.6 October 8, 2005 Kashmir earthquake triggered several thousand landslides throughout the Himalayas of northern Pakistan and India. A multi-criterion evaluation was applied to determine the significance of event controlling parameters in triggering the landslides. The parameters included lithology, faults, slope gradient, slope aspect, elevation, land cover, river sand roads. The results showed four classes of landslide susceptibility. Furthermore, they indicated that lithology had the strongest influence on land sliding, particularly when the rock is highly fractured, such as in shale, slate, classic sediments, and limestone and dolomite. Moreover, the proximity of the landslides to faults, rivers, and roads was also an important factor in helping to initiate failures. In addition, landslides. Occurred particularly in moderate elevations on south facing slopes. Slopes are susceptible to failure during an earthquake and can collapse constitute a possible landslide threat as a consequence, it's important to analyze these potential failure slopes in the future. Slope gradient had the second highest influence as an event-controlling parameter, and most of the landslides occurred on slopes from 25–35°.

[4] NATIONAL DISASTER MANAGEMENT GUIDELINES GOI(GOVT. of INDIA) et al.,2009. Landslides are one of the natural hazards that harm at least 15percent of our country's land area, which is greater than 0.49 million km2. Landslides of various forms are common in the country's geo dynamically active domains, such as the Himalayan and North-Eastern regions, as well as the more stable domains of the Meghalaya Plateau, Western Ghats, and Nilgiri Hills. This hazard affects 22 states as well as sections of the Union Territory of Pondicherry and the Andaman and Nicobar Islands. Landslides are a common occurrence during the monsoon season. Landslides have traditionally had terrible results, generating massive economic losses and disrupting social structures. In only one year, more than 500 people died as a result of climate change in our country

[5] Lucio Olivares et al.,2009. The mechanics of rainfall-induced flow slides in pyroclastic soils have yet to be completely clarified. The complexity of phenomena (rainfall-induced failure in initially unsaturated granular de- posits, post-failure transition to flow-like landslide) requires the use of a well- equipped small-scale flume. To this aim, flume experiments at the Second University of Naples were performed to analyze the fundamental aspects of such phenomena. A new experimental program is now being carried out to assess the performance of a time domain reflectometry device and optical fibers as indicators of impending failure. The paper describes the instrumented flume and the procedures adopted for monitoring the major aspects of slope behavior. Our first experimental results are very promising in this respect.

[6] Ghosh and Bhattacharya, 2010. The susceptibility of a region to land- slides is significant for both socioeconomic and engineering purposes. As a result, an automated framework for mapping landslide susceptibility could be extremely good for society. Landslide formation is an evolutionary and deadly force, thereby making it a major cause of concern for human life and property. Intensification of land use changes in mountainous regions for different socioeconomic activities (e.g., urban expansion, road building, deforestation, etc.) increases the potential for landslides and results in adverse impacts (Aleotti and Choudhury 1999). The large amount of data and parameters that must be compared in order to arrive at a conclusion about landslide vulnerability for a given area necessitates the creation of an automated system capable of estimating the severity of possible landslides in a given area.

[7] Pradhan et al., 2010. Landslides are serious types of natural disasters. Historically, the study area, a component of Penang Hill south of Penang Island, Malaysia, has suffered from frequent landslides (cliff collapses, landslides, mudslides, etc.). Most of these landslides are triggered by sensitive geological, geomorphological and climatological conditions as well as anthropological activities. The landslides in the study area not only destroyed the agricultural lands and closed the roads, but also reduced the water holding capacity. It is difficult to accurately determine the status, shape and behavior of landslides to determine landslide inventory records. The findings of this study provide a scientific framework for assessing landslide risk areas and should be used as a basis

for decision making by relevant authorities. Findings are often used as a starting point for slope management and land use planning within the study area.

[8] T. SUBRAMANI et al, 2012 "Application of Eco-Friendly Geotextiles for Landslide Mitigation in Part of Ooty Hills, Tamil Nadu" is the subject of this study. Precipitation/snowfall, tectonic activity and human activities are the main landslide triggers. The aim of the research was to learn more about the use of geotextile in slope stabilization. Ooty is one of the most prone to landslides in India. Landslides take the lives and property of many people every year. The present research was conducted in the Kattery basin. Using GIS, many thematic maps related to landslide hazard assessments were created from the top pages and satellite images. The Kattery basin is divided into two halves, one in the north and the other in the south. The physical, chemical and engineering properties of the soil were examined in the laboratory and it was determined that the soil was classified as an inorganic soil with low plasticity.

[9] F. Shaikh et al., 2015 The title of this document is "HEYLAN REPORT IN MALI VILLAGE, PUNE." This report was developed to investigate the incidence of rapid landslides in slope development areas in Pune, Malin, western India. According to reports, this area was hit by extremely heavy monsoon rains in the two days leading up to the landslide. Variables that cause landslides, both natural and man-made activities, the impact of landslides and appropriate mitigation strategies are discussed in this paper.

[10] P.B. Gavali,et al.,2017 Landslides caused by heavy rains are increasing in the Western Ghats, making it critical to identify landslide-prone locations beforehand. Precipitation, slope, lithology, land use and land cover (LULC), soil characteristics, relative relief, aspect and lineament are the eight weighted landslide indicators used to identify landslide susceptible villages (LSV) in the Kalsubai region of the Deccan volcanic province (DVP).), Maharashtra, India. These factors were matched with advanced remote sensing (RS) data and processed in a geographic information system (GIS) and image processing software, both of which are important components of geospatial approaches. In the study, out of a total of 59 villages, 9 were determined from extreme high, 13 high, 12 medium and 11 low risk areas.

[11] Shu-Rong Yang 2017 In general, the effect of precipitation on a slope can result in reducing soil absorption, increasing positive pore pressure, increasing soil unit weight, and reducing the shear strength of rock and soil, thus landslides (Iverson and Major 1986) . Slope unit-based landslide susceptibility maps were then validated by predicting samples and data from an important rainfall case. During this study, the typical cumulative rainfall is found to be significant within the understanding of landslide distribution. this is often a big factor. When it involves this landslide forecast, it's sup- ported a rainfall distribution scenario. The model are often wont to predict spatial distribution and occurrence. Future landslides are possible. It are often utilized in practice also as mitigation of landslide risks. during this study, the typical cumulative rainfall is found to be significant within the understanding of landslide distribution. this is often a big factor. When it involves this landslide forecast, it's supported a rainfall distribution scenario. The models often predict the spatial distribution and occurrence of future landslides. It is often utilized in practice also as in mitigation of landslide risks for Taiwan.

[12] Javed Iqbal et al, 2017 The main aim of this research is to use various methodologies to better understand reservoir landslide threats and mechanisms. The devastating Vaiont landslide in 1963, which caused severe destruction and loss of life, was the first time reservoir landslides have been extensively investigated. This landslide set a precedent, causing a shift in focus on reservoir slope stability. Of the existing landslides, 0.36 percent in very low sensitivity areas, 1.77 percent in low sensitivity areas, 4.14% in medium sensitivity areas, 6.04 percent in high sensitivity areas, and 13.37 percent in high sensitivity areas. Discovered to occur in areas of very high sensitivity. by superimposing existing landslide and susceptibility maps.

[13] Strouth, A., McDougall, S. 2021. Taking risks is a necessary aspect of life. We evaluate risks naturally and even subconsciously as people by weighing perceived dangers against expected advantages. When we decide to speed home from work or go for a swim, we do this so frequently that it goes unnoticed. When one institution (such as the government) imposes a risk assessment on another person, the comparison changes. Taking risks is a necessary aspect of life. We evaluate risks naturally and even subconsciously as people by weighing perceived dangers against expected advantages.

GIS and Remote Sensing Susceptibility Mapping

a) Saro Lee, Biswajeet Pradhan 2006l. [14] The purpose of this article is to examine the landslide hazards and risk analysis in Penang Island, Malaysia using Geographic Information System (GIS) and remote sensing data. The landslide locations in the study area were determined from the interpretation of aerial photographs and field surveys. Topographic and geological data and satellite images were collected and processed using GIS and image processing tools. There are ten landslide-causing parameters taken into account for the landslide hazard analysis. Landslide susceptibility maps were created using the relationship between each landslide and its causative factors. In this study, a probabilistic approach is presented to predict landslide-prone areas using GIS and remote sensing.

b) Iswar Das et al., 2010 [15] Ground awareness and field measurements of rock strength and slope failure parameters are widely used to guide landslide investigations. However, as GIS-based statistical approaches evolve, landslide susceptibility studies benefit from combining data from different sources and methods at various scales. This article demonstrates a logistic regression approach for landslide susceptibility mapping and compares the findings with a geotechnical-based slope stability probability classification (SSPC) methodology. Geotechnical methods such as SSPC give better results when applied to a hill-cut road section for landslide susceptibility mapping. This research can be used to prepare future hazard and risk management projects along highway road corridors using one of the main approaches in landslide susceptibility mapping.

c) Miau-Bin Su et al, 2009 [16] Time domain reflectometry (TDR) is used in conjunction with global positioning system (GPS) to monitor ground deformation of high altitude landslides in Li-shan. Monitoring methods for slope subsurface deformation. The most critical factors in a landslide monitoring system are to evaluate the position of the slip surface and the distribution of displacements. Conventional monitoring equipment is not always suitable for large-scale landslides or landslides in high-altitude mountain areas.

The use of TDR coaxial cables and GPS to monitor landslides in high mountain areas has proven beneficial for landslides occurring on highly eroded rock slopes. As a conventional in situ inclinometer, the TDR system, consisting of coaxial cables jointed in a drill hole, can sense slip surfaces and their motion.

d) Pradhan et al., 2010 [17] Results of cross-validation of a frequency ratio model for landslide susceptibility analysis using remote sensing data and GIS are presented in this paper. The landslide locations of the study areas were determined by analyzing the aerial photographs and satellite photographs enriched by field studies. The results of the tests were then compared to field-confirmed landslide locations for verification. Tropical rains and flash floods in Malaysia cause rock surface degradation along fracture, joint and cleavage planes, resulting in landslides. The country's geology is relatively stable, but continued growth and urbanization has caused deforestation and degradation of the soil layers covering the slopes, posing serious threats to the slopes. Landslide susceptibility maps are especially useful for designers and engineers in finding suitable construction sites.

e) V.k.kumra et al., 2014 [18] Mapping of Landslide Hazard Using Remote Sensing and GIS". This landslide research has gotten a lot of attention because people are becoming more aware of the socioeconomic consequences of landslides. By integrating meaningful land use information from remote sensing photographs with other spatial parameters that affect the incidence of landslides in a GIS environment, the occurrence of landslides can be predicted. A landslide inventory is a necessary component of a GIS-based landslide hazard analysis. LANDSAT ETM+, IRS P6, ASTER and other satellite imagery and Survey of India (SOI) topographic tables are used to obtain basic information on slope, aspect, relative relief, drainage density, geology/lithology and land use. /land cover.

f) Rakesh l.Metha et al., 2015 [19] A landslide near Mahabaleshwar, Maharashtra, India, prone area". The proposed study is a set of tools for detecting and mapping possible mass movements and their damage potential. The region bordered by a pre-existing landslide in Bhilar, Maharashtra, was chosen for this investigation. In addition, a geo-informatics strategy using remote sensing data and GIS as a software-integrated tool for Landslide Hazard zonation is being investigated. The numerous spectral signatures and image interpretation keys in relation to slope instability, as well as various image data to detect pre-occurred events and vulnerable places, are examined and applied. The process takes into ac- count lithology, slope, morphology, slope aspect, soil, relief, drainage, land use, and pre-existing landslides in the region, all of which are created utilizing remote sensing data and GIS tools. In the high-risk zone, vulnerability zonation mapping and analysis of settlements and infrastructure facilities were completed.

g) Chawla et al., 2017 [20] Transition from a stable slope to an unstable slope is the most important consideration about the occurrence of landslides. A change in slope stability can also result from the spread of things working together or separately. The forcing of spilled waters, loss or absence of vertical vegetative structure, load-added earthquakes and volcanic eruptions are natural causes of landslides. In this study, GIS and remote sensing are widely used to combine landslide susceptibility maps. The application and integration of satellite data greatly improved the standard of terrain features in the image. For planning or implementing an on-site replacement development project, a sensitivity map can assist in decision making. Avoiding extremely sensitive areas is highly recommended, but if impossible, corrective measures should be taken to minimize the possibility of landslides occurring.

h) Jiale Li et al 2017 [21] People are at risk of landslides, one of the most devastating natural disasters. Most of these landslides are caused by low strength soils and the presence of groundwater. Widespread movement of these soils occurs after the soils are wetted by the spring rains. The goal is to strategically place anions and stimuli in ditches to aid the migration of these chemical components as dissolved species via groundwater transport. The main disadvantage of renewable energy is its high initial cost, which is easily compensated over its estimated operational life. Consequently, using a portable renewable energy generator for electrochemical stabilization is a potentially environmentally friendly option. Landslides are a natural phenomenon.

i) Purnanand Savoikar et al., 2018 [22] Landslides are a worldwide hazard arising from the instability of soil slopes. Slope stability survey, planning and control has become more important as practically all construction and mining operations require cutting or filling slopes in addition to natural slopes and embankments. In this article, three case studies including new retaining structures and forensic investigations of landslides are reviewed. Geo-studio 2012 was used to perform static and seismic slope stability analyses. Morgenstern – Price approach was used to analyze the models in the static condition, and then the models were analyzed in the seismic condition using the same geometry and material parameters. Under the QUAKE/W module of the GEO-STUDUIO package, the time history record of the Kobe earthquake is used. Study. After adopting slope protection measures, stability analysis was performed using Optum G2 software. Slope protection systems such as RCC retaining walls, reinforced earth walls, soil nailing walls, gabion walls, tie back walls, and so on must be implemented while taking into account different parameters such as slope height, soil type, and so on Construction space availability, cost, long-term durability, and so forth. Newer strategies, such as alleviating platform techniques or controlled yielding techniques, need to be considered as well. This is what their article, "Landslides – Stability and Control Measures"

j) Chawla et al, 2018 [23] Landslides are a temporary and unpredictable natural disaster in the mountains, but they can easily turn into a disaster factor that causes landscape changes over time due to immature geology and external influences, and there are also direct and indirect losses. This study presents a methodology for generating landslide susceptibility maps using remote sensing data and Geographical Information System techniques for a part of Darjeeling region in India located in the Eastern Himalaya. It is time to conduct a comprehensive landslide threat analysis of the very high and high sensitivity regions of the study area, particularly in terms of suggesting mitigation measures and geotechnical solutions to reduce slope stability. An LSZ map of the study area would be helpful. A set of programs and disaster prevention initiatives in making future planning decisions.

k) K. Sassa., 2019 [24] The International Landslide Consortium (ICL) held its first Board of Representatives (BOR) meeting on 19–21 November 2002 at UNESCO headquarters. The scientific program of the session, the International Program on Landslides (IPL), was established to provide international assistance. ICL sought approval and guidance for the co-programmers it recommended. Geologists, urban and urban planning personnel, agricultural and forest researchers, and some terms such as

"technical terminology" and "basic sciences" are not interchangeable for certain fields involving landslides, such as geologists, geo morphologists, civil engineers, and mining engineers.

l) Dikşit et al. 2020 [25] Landslides are one of the most dangerous and widespread natural disasters to hit hilly areas all over the world. In the Indian Himalayan region, landslides are common, damaging vital economic sectors, including transportation and agriculture, and often resulting in fatalities. Landslides are one of the most common natural disasters in the world, affecting people and their livelihoods. Compared to other parts of the world, the Himalayas have a very high rate of occurrence. This study also examines various landslide monitoring and analysis procedures, as well as reporting on various mitigation measures and newer applications of Geographic Information Systems (GIS) function, remote sensing and computational techniques. According to various studies, a severe lack of ground-based precipitation data has been discovered in large parts of the Himalayan region. To solve this problem, start comparing and finding data from remote sensors. The best dataset to use for individual sections in the Himalayan region.

m) Perera et al. 2020 [26] Landslides in Sri Lanka have become a widespread natural hazard and a serious environmental problem. The increases in high-intensity rainfall events, increased population, plantation growth, and the country's lifelines have all contributed to the increased landslide hazard. Landslides are increasingly common around the world and have a significant socioeconomic impact on human life lost over the past two decades. This research was conducted using a system that combines various methodologies based on the GIS platform. The computer's ability to predict the future Adopting a built-in risk index with consistent weights can help improve the accuracy of the variable or indicator. The installed system is open source and regularly updated is quite simple for local governments. For policy makers, the findings are simple. Finally, it is recommended to use this framework. Hazard variability is spatially and temporally variable, with real-time alerts for more reliable predictions.

n) Ichard Mind'je et al.2020 [27] As a landlocked country heavily dependent on the environment and socioeconomic growth, Rwanda regularly grapples with massive and deadly landslides. Analyzing landslide susceptibility and the factors affecting it can help landslide management and ultimately environmental sustainability. Unfortunately, accurate data is not easily available. Information on the contributing factors of each class and their degree of correlation. The risk of landslides in Rwanda has not been fully studied. The findings of this research can be used to recommend a sustained early warning system for places expected to be severely affected by future climate-related disasters and assist disaster preparedness, prevention and recovery efforts. Existing environmental and land use policies and plans should be updated to ensure long-term sustainability. Furthermore, the landslide susceptibility model can be a useful reference for future research and encourage greater attention to the promotion of landslides.

o) Nakileza and Nedala 2020 [28] The aim of this study was to determine how topography affects landslide characteristics and to examine implications for risk management in a tropical mountainous environment. A database was created using landslide inventories. Field surveys and desk research were used to support the findings. A 30m resolution STRM DEM was used to obtain topographic information for the research area. Data analysis was completed using Arc GIS 10.5 software. The frequency ratio of the prototype was used to investigate the relationship between landslides and topographic conditioning factors. It is important not to overlook strategies to reduce the risk of slope collapse. In addition to topography factors (slope angle, curvature), ensure safe runoff disposal and develop green solutions for highly sensitive areas.

p) Nakileza and Nedala 2020 [29] Landslides have been identified as the most destructive natural disasters in mountainous regions in the world. Mass movements in mountainous terrain can be dangerous due to triggering and predisposing/conditional causal variables. hand, geology, weathering, soil and terrain, considerate the ones who cause slope instability. Anthropogenic Mountainous environments are prone to a variety of problems. The development of unstable places in the earth's substance slopes of the hill (Nefeslioglu et al.)This study set out to investigate the topographic influence on the pattern and spatial-temporal distribution of landslides, and implications on risk management in the selected upper catchment of R. Manafwa.

q) Gabriel Legorreta Paulin et al, 2020 [30] Virtual depiction of topography through the use of high-resolution digital elevation models (DEMs) generated by light sensing and distance determination has assisted the geomorphological study of landslide processes in rugged terrains with limited access. . For volume calculation, general overlay and interpolation models utilize high resolution DEMS. These challenges are compounded by state or national landslide hazard zoning mapping efforts where models must be used for large datasets. To address the above-mentioned shortcoming, this research proposes a method for estimating landslide volume generation and distribution using LiDAR and standardizing landslide volume calculation in a geographic information system (GIS).

IV. Conclusions

This section provides a summary of what will be learned about the practice of landslide mapping and analysis in the normal lifestyle so that it does not hurt anyone and offers some suggestions for future research in this area. Now a day the weather on the earth's surface is changing drastically. Precipitation conditions also vary. With the Precipitation increasing. Landslides occur mostly in places where precipitation is intense, slope is wide, soil properties suitable for landslides, water resources are available, and vegetation index is low. There is a need for landslide susceptibility and mapping studies. If we get accurate results for landslide prediction, it will be very helpful for mitigation planning of landslide prone areas. Since some areas included in the analysis have a high population density, people should be made aware that the area they live in is a landslide area so that they can take the necessary precautions in heavy rains.

References

[1] W. Zuoan, L. Shihai, J.-G. Wang, and W. Ling, "A dynamic comprehensivemethod for landslide control," Engineering geology, vol. 84, no. 1-2, pp. 1–11,2006.

[2] Rotaru, D. Oajdea, and P. R˘aileanu, "Analysis of the landslide movements," International Journal of Geology, vol. 1, no. 3, pp. 70–79, 2007.

[3] U. Kamp, B. J. Growley, G. A. Khattak, and L. A. Owen, "Gis-based landslide susceptibility mapping for the 2005 Kashmir earthquake region," Geomorphology, vol. 101, no. 4, pp. 631–642, 2008.
[4] G. of India, "National disaster management guidelines: Management of land- slides and snow avalanches," 2009.
[5] L. Olivares, E. Damiano, R. Greco, L. Zeni, L. Picarelli, A. Minardo, A. Guida, and R. Bernini, "An instrumented flume to investigate the mechanics of rainfall induced landslides in unsaturated granular soils," Geotechnical Testing Journal, vol. 32, no. 2, pp. 108–118, 2009.
[6] J. K. Ghosh and D. Bhattacharya, "Knowledge-based landslide susceptibility zonation system," Journal of Computing in civil engineering, vol. 24, no. 4, pp. 325–334, 2010.
[7] B. Pradhan, S. Lee, and M. F. Buchroithner, "Remote sensing and GIS based landslide susceptibility analysis and its cross-validation in three test areas us- ing a frequency ratio model," PFG Photogrammetry, Fernerkundung, Geoinformation, pp. 17–32, 2010.
[8] T. Subramani, "Application of eco-friendly geotextiles for landslide mitigation in a part of ooty hills, tamilnadu," International Journal of Modern Engineering Research, vol. 2, no. 3, pp. 579–585, 2012.
[9] Shaikh, P. Gunjal, and N. Chaple, "Report on landslide in Malin village in Pune," 2015.
[10] S.-R. Yang, "Assessment of rainfall-induced landslide susceptibility using GIS based slope unit approach," Journal of Performance of Constructed Facilities, vol. 31, no. 4, p. 04017026, 2017.
[11] P. B. Gawali, S. P. Aher, B. Lakshmi, R. D. Gaikwad, K. Deendayalan, P. T. Hanamgond, J. M. Babu, S. A. Arote, and S. I. Bairage, "Identification of landslide susceptible villages around kalsubai region, western Ghats of ma- harashtra using geospatial techniques," Journal of the Geological Society of India, vol. 90, no. 3, pp. 301–311, 2017.
[12] G.-l. Du, Y.-s. Zhang, J. Iqbal, Z.-h. Yang, and X. Yao, "Landslide susceptibility mapping using an integrated model of information value method and logistic regression in the bailongjiang watershed, gansu province, china," Journal of Mountain Science, vol. 14, no. 2, pp. 249–268, 2017.
[13] Strouth and S. McDougall, "Societal risk evaluation for landslides: historical synthesis and proposed tools," Landslides, vol. 18, no. 3, pp. 1071–1085, 2021.
[14] S. Lee and B. Pradhan, "Probabilistic landslide hazards and risk mapping on Penang island, Malaysia," Journal of Earth System Science, vol. 115, no. 6,pp. 661–672, 2006.
[15] Das, S. Sahoo, C. van Westen, A. Stein, and R. Hack, "Landslide susceptibility assessment using logistic regression and its comparison with a rock mass classification system, along a road section in the northern Himalayas (India)," Geomorphology, vol. 114, no. 4, pp. 627–637, 2010.
[16] M.-B. Su, I.-H. Chen, and C.-H. Liao, "Using tdr cables and gps for landslide monitoring in high mountain area," Journal of geotechnical and geoenviron- mental engineering, vol. 135, no. 8, pp. 1113–1121, 2009.
[17] B. Pradhan, S. Lee, and M. F. Buchroithner, "Remote sensing and gis-based landslide susceptibility analysis and its cross-validation in three test areas us- ing a frequency ratio model," PFG Photogrammetrie, Fernerkundung, Geoinformation, pp. 17–32, 2010.
[18] Pandey, P. Dabral, V. Chowdary, and N. Yadav, "Landslide hazard zonation using remote sensing and GIS: a case study of dikrong river basin, arunachal pradesh, india," Environmental geology, vol. 54, no. 7, pp. 1517– 1529, 2008.
[19] R. L. Metha, S. R. Koli, and V. R. Koli, "Landslide hazard zonation using remote sensing and gis technology: A case study of landslide prone area near mahabaleshwar, maharashtra," 2015.
[20] S. Chawla, A. Chawla, and S. Pasupuleti, "A feasible approach for landslidesusceptibility map using GIS," in Geo-Risk 2017, pp. 101–110, 2017.
[21] J. Li and X. Yu, "Feasibility analyses of using renewable wind energy for landslide mitigation," in Geotechnical Frontiers 2017, pp. 382–389, 2017.
[22] J. Thorneycroft, J. Orr, P. Savoikar, and R. Ball, "Performance of structural concrete with recycled plastic waste as a partial replacement for sand," Construction and Building Materials, vol. 161, pp. 63–69, 2018.
[23] Chawla, S. Chawla, S. Pasupuleti, A. Rao, K. Sarkar, and R. Dwivedi, "Landslide susceptibility mapping in darjeeling Himalayas, India," Advances in Civil Engineering, vol. 2018, 2018.
[24] K. Sassa, "The fifth world landslide forum and the final draft of the kyoto 2020 commitment," Landslides, vol. 16, no. 2, pp. 201–211, 2019.
[25] Dikshit, R. Sarkar, B. Pradhan, S. Segoni, and A. M. Alamri, "Rainfall induced landslide studies in Indian Himalayan region: A critical review," Applied Sciences, vol. 10, no. 7, p. 2466, 2020.
[26] C. Perera, K. Gimhani, C. Gunaratne, and P. Kuruppuarachchi, "Spatiotemporal variability of landslides as a consequence of land cover changes: A case study from kegalle district," in Proceedings of International Forestry and Environment Symposium, vol. 25, 2020.
[27] R. Mind'je, L. Li, J. B. Nsengiyumva, C. Mupenzi, E. M. Nyesheja, P. M. Kayumba, A. Gasirabo, and E. Hakorimana, "Landslide susceptibility and influencing factors analysis in Rwanda," Environment, Development and Sustainability, pp. 1–28, 2019.
[28] B. R. Nakileza and S. Nedala, "Topographic influence on landslides characteristics and implication for risk management in upper manafwa catchment, mt elgon Uganda," Geoenvironmental Disasters, vol. 7, no. 1, pp. 1–13, 2020.
[29] M. Akshaya, J. H. Danumah, S. Saha, R. Ajin, and S. L. Kuriakose, "Landslide susceptibility zonation of the western ghats region in Thiruvananthapuram district (kerala) using geospatial tools: A comparison of the ahp and fuzzy-ahp methods," Safety in Extreme Environments, vol. 3, no. 3, pp. 181– 202, 2021.
[30] G. L. Paulin, T. A. Contreras, K. A. Mickelson, K. E. Jacobacci, and W. Gallin, "Modeling landslide volumes: A case study in Whatcom county, Washington, USA," in Workshop on World Landslide Forum, pp. 371–375, Springer, 2020.

BIOGRAPHY

1 Mr. Vaibhav B Kashyap.
PG Scholar. M.Tech – Environmental Science & Technology, Department of Technology, Shivaji University. Kolhapur. Maharashtra. India

2 Prof. Shrikant M Bhosale.
Co-ordinator.
M.Tech Environmental Science & technology. Department of Technology, Shivaji University, Kolhapur Maharashtra. India

3 Dr. Jalandar. D. Patil.
Research Professor.
Department of Technology, Shivaji University, Kolhapur. Maharashtra. India.