International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Landslide Hazard Analysis and Zonation in Shimla City: A Geospatial Approach

Rekha Yadav

MSc (Geograhpy)

Abstract: ***The Himalayan region, with its complex geological and topographical features, is highly susceptible to landslides, and Shimla City, nestled in the foothills of the Himalayas, is no exception. This research paper explores the critical issue of landslide hazards in Shimla City using a geospatial approach, with a focus on susceptibility analysis and zonation. Our study involves the collection and analysis of a comprehensive dataset, including geological, meteorological, and topographical information. Geospatial tools and technologies were employed to assess landslide susceptibility, combining factors such as soil type, slope angle, land use, and historical landslide occurrence. Through this analysis, we have identified and categorized areas in Shimla City into high, moderate, and low - risk zones, enabling the development of a detailed landslide hazard zonation map. Key findings of this research paper include the identification of specific regions within Shimla City that are at the highest risk of landslides. We have also determined the influence of geological features and meteorological conditions on landslide occurrences. Moreover, case studies of past landslides in Shimla City provide valuable insights into the real - world implications of these hazards. This study underscores the urgency of proactive landslide risk management in Shimla, especially as urbanization and infrastructure development continue to encroach upon vulnerable areas. Our findings contribute to the growing body of knowledge on landslide hazards in hilly terrains and provide a foundation for informed urban planning, disaster preparedness, and mitigation efforts. By implementing the recommendations derived from this research, authorities and stakeholders can work towards a safer and more sustainable future for Shimla City and other regions facing similar challenges. The output reveals that the entire Shimla falls under four categories of vulnerability ranging from very low vulnerability to high vulnerability.62.02% of the Shimla is prone to low hazard followed by very low at 26.10%, moderate at 11.55%, and high covering only 0.32%. Most of the major settlements are located along moderately vulnerable area.***

Keywords: Landslide hazards evolution factor, Geological and Metrological

1. Introduction

Nestled in the picturesque foothills of the Himalayas, Shimla City stands as an iconic representation of natural beauty and colonial heritage. However, behind this captivating facade lies a complex geological and topographical setting that poses a persistent and imminent threat - landslides. The significance of landslide hazard analysis in Shimla cannot be overstated, as it is fundamental to the preservation of life, infrastructure, and the sustainable development of the city.

Shimla's geographical terrain, marked by steep slopes, geological diversity, and climatic variability, renders it highly susceptible to landslides. To comprehend these natural processes, which can be induced by a combination of factors, such as heavy monsoon rains, seismic activity, and human - induced alterations to the landscape, is paramount.

In India, about 0.42 million kilometer of the land area excluding snow cover areas are prone to land slide hazard. Out of this 0.14 million kilometer of the area fall under north east Himalaya. The Himalaya region more prone to slope instability due to its rugged terrain. Each year the state is affected by one or more major land slide causing social and economic loses. Loses of life, damages to houses, roads, communication lines, agricultural lands are some of the example.

2. Objective

1) To categorize the various layers into vulnerable hazards using landslide hazards evolution factor.
2) To describe landslide vulnerable zone using weighted overlay method.
3) To describe reasons behind landslide using evolution methods.

Study Area

Shimla is often referred to as the “Queen of Hills”, a term coined by the British, is a very popular tourist destination. The city is located in the north - west Himalayas at an average altitude of 2, 205 meter (7, 234 ft). The city is spread on a ridge and its seven spurs. The city of Shimla, draped in evergreen glades of pine, deodar, oak and rhododendron, experiences pleasant summers and cold, snowy winters. The coordinates of Shimla are 31°6’12’’ North and 77°10’20’’ East. It has an area of 31.60 sq. km and stretches nearly 9.2 km from east to west. According to 2011 census data, Total Population of Shimla tehsil is 1, 71, 640 among which 1, 69, 578 of them resides in Shimla municipal corporation and 2, 062 of them belongs to Shimla rural monitored by Jutog cantonment board. The literacy rate 93.63% which is greater than the literacy rate of Himachal Pradesh 82.8%. Satluj, Pabbar and Giri are the three main rivers that drain through the Shimla Tehsil. Timber and Charcoal are the important forest. Agriculture and Horticulture are the important economic activities of Shimla. The soil is grey wooded or podzolic soil. Geographically, the rock formations in Shimla ranges from pre Cambrian to quaternary period, climate is subtropical in valley and hilltop temperate type. Average rainfall in Shimla is 999.3 milimeter.

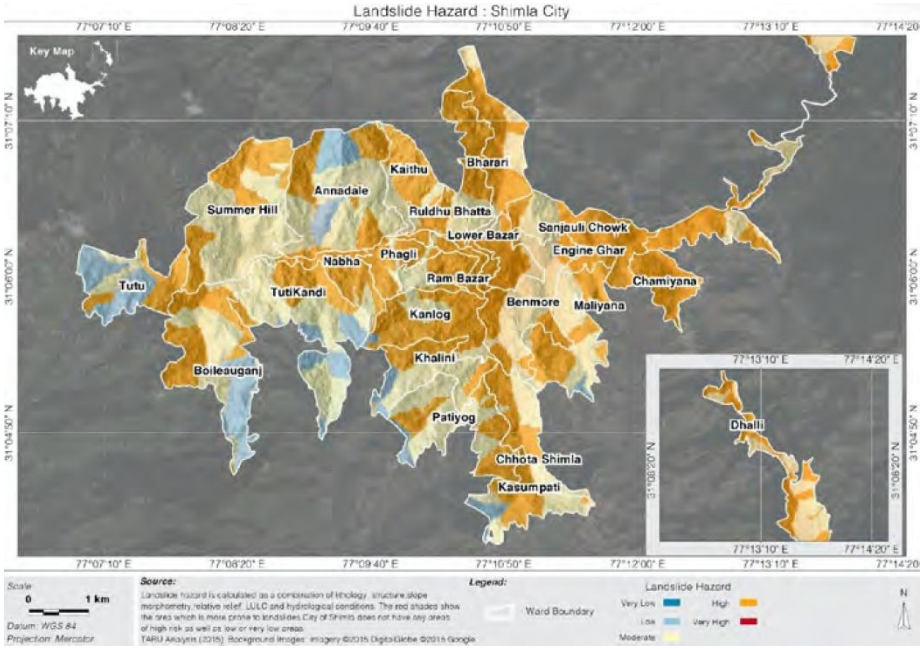
3. Methodology

- Describe the data sources and collection methods, including geological, meteorological, and topographical data.
- Explain the use of geospatial tools and technologies for landslide hazard analysis.
- Outline the steps involved in hazard analysis, such as data preprocessing, susceptibility assessment, and zonation.

Geological and Meteorological Analysis:

- Present the geological characteristics of Shimla and their impact on landslide susceptibility. Geologically, the rock formation in Shimla ranges from Precambrian to quaternary period. Most part of the district is covered by hard rock.
- Analyze the meteorological factors like rainfall patterns, temperature, and their influence on landslide occurrence. Shimla experiences a monsoon - influenced climate, with the majority of its rainfall occurring during the monsoon season from June to September. The heavy and prolonged monsoon rains saturate the soil and rocks, increasing their weight and reducing their stability. This heightened water content, in combination with the region's steep slopes and weak geological formations, significantly elevates the risk of landslides.
- Landslides are downward sliding movement of soil, debris or rocks, resulting from natural causes, vibrations, overburden of rock material, removal of lateral supports, change in the water content of rock or soil bodies, blocked drainage etc. Landslide is a very common hazard in Himachal Pradesh as well as Shimla city, which causes immense loss of infrastructure, property and sometimes life too. The fragile nature of rocks forming the mountains along with the climatic conditions and various anthropogenic activities has made the city vulnerable to landslides. Overloaded slopes may initially cause only minor landslides, but at later stage could trigger larger landslides. Many areas of the town become prone to landslides especially during the rainy season. Table 9 shows the Economic losses caused by rains in Shimla city in the past 8 years.

Landslide hazard map of Shimla City



Source: - Hazard risk and vulnerability assessment of Shimla city

Losses caused by rain damaged occurred within Shimla

Sr. No.	Financial Year	Loss (In Crores)
1.	2015 - 16	3.25
2.	2016 - 17	4.16
3.	2017 - 18	11.02
4.	2018 - 19	7.48
5.	2019 - 20	3.86
6.	2020 - 21	13.80
7.	2021 - 22	5.27
8.	2022 - 23	7.5

Source – Municipal Corporation Shimla

Land slide hazard

Kalka - Shimla rail track damaged due to land slide.

Rock slide occurred along the Shiv Mandir in Summer Hill Shimla

Landslide Zonation:
After assigning corresponding LHEF values for the six landslide parameters (lithology, structure, slope morphometry, relative relief, LULC and hydrological conditions) as per BIS 14496 Part 2: 1998, the assigned values have been summed up for calculation of the total estimated hazard (TEHD) for the area for undertaking the study. The TEHD values for the area fall under three categories - low hazard zone (TEHD value between 3.5 and 5.0), moderate hazard zone (TEHD value between 5.1 and 6.0) and, high hazard zone (TEHD value between 6.1 and 7.5).43 facets (16% of the area) of the area fall under low hazard, 141 facets (51% of the area) fall under moderate hazard and 92 facets (33% of the area) are under high hazard category. Apparently, the hazard scenario of the area is fairly high. It is to be mentioned here that being placed under even the low and moderate hazard conditions does not allow much scope for complacency in a place like Shimla as in present times when anthropogenic interference is a major contributing factor in causing instability of the slopes. This also adds to the fact that modification of the present geo - environmental parameters like land use practices, slope modification, unchannelised slope water are likely to increase the susceptibility of the area which is undergoing a lot of change in land use pattern.

Reasons behind Landslides:

- **Geologically weak material:** Weathered materials, jointed or fissured materials, contrast in permeability and contrast in stiffness (stiff, dense material over plastic materials).
- **Erosion:** Wave erosion of slope toe, glacial erosion of slope toe, subterranean erosion (Deposition loading slope or its crest, Vegetation removal.
- **Intense rainfall:** Storms that produce intense rainfall for periods as short as several hours or have a more moderate intensity lasting several days have triggered abundant landslides.
- **Human Excavation of slope**and its toe loading of slope/toe, draw down in reservoir, mining, deforestation, irrigation, vibration/blast, water leakage from services. Earthquake shaking could trigger landslides in many different topographic and geologic settings. Rock falls, soil slides and rockslides from steep slopes involving relatively thin or shallow dis - aggregated soils or rock, or both have been the most abundant types of landslides triggered by historical earthquakes.

4. Conclusion

The primary findings of this research encompass the identification of high landslide risk areas in Shimla. We have examined the impact of geological characteristics and meteorological conditions on landslide occurrences. Additionally, we have provided valuable insights into the real - world consequences of past landslides in Shimla.

Emphasize the importance of proactive landslide risk management in Shimla:

- The significance of proactive landslide risk management in Shimla cannot be overstated. Without it, urban expansion and infrastructure development can pose increased risks in vulnerable areas. Furthermore, in the context of climate change, where the frequency and intensity of extreme weather events are on the rise, it becomes even more crucial.

5. Suggest Future Research Directions

For future research, we can explore new technologies in landslide science that could be beneficial for informed and secure landslide management. Furthermore, more extensive data collection, refined landslide estimation, and utilization of advanced tools for public awareness programs can be crucial. Additionally, understanding the socio - economic impacts of landslides and developing strategies to mitigate them should be a priority for further research.

The Geological Survey of India (GSI) is also currently updating its earlier studies on the town to assess the disaster - causing potential of its unstable slopes. GSI's former Deputy Director - General PN Razdan says, "The problem of landslides in Shimla town is aggravating and we feel that the town needs urgent treatment for this. Our study will identify the vulnerable areas and suggest remedial measures. "

References

[1] Preparation of landslide hazard zonation maps in mountainous terrain—guidelines (Part2 - Macrozonation). In: Bureau of Indian Standards, vol 14496, 2nd edn. BIS, New Delhi, pp 1–19 (1998).
[2] Panikkar SV, Subramanyan V (1996) A geomorphic evaluation of the landslides around Dehradun and Mussoorie, Uttar Pradesh, India. Geomorphology 15 (2): 169–181. https: //doi. org/10.1016/0169 - 555X (95) 00121 - K.
[3] Kanungo D, Arrora M, Sarkar S, Gupta R (2009) Landslide susceptibility zonation (LSZ) mapping - a review. J South Asia Disaster Stud.
[4] Panikkar S, Subramaniyan V (1997) Landslide hazard analysis of the area around Dehra Dun and Mussoorie, Uttar Pradesh.
[5] Naithani A (2007) Macro landslide hazard zonation mapping using univariate statistical analysis in parts of Garhwal Himalaya. J Geol Soc India.
[6] Census 2011 list for Himachal Pradesh. http: //www.census2011. co. in/census/city/4 - shimla. html.
[7] District state disaster management plan. http: //www.hpsdma. nic. in/Disaster Management / SDMP. html.