International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 07 | July - 2022 Impact Factor: 7.185 ISSN: 2582-3930

VULNERABILITY MAPPING OF LANDSLIDE VIA GIS

TAMIM HAMSAR[1], AMIT TALGOTRA[2]

[1]M. Tech Scholar

[2]Assistant Professor,

[1]Civil Engineering,

Sri Sai College of Engineering and Technology Badhani, Pathankot

ABSTRACT:- In the present study detailed work has been carried out in andaround Udhampur, Jammu and kashmir, India with the main objective of demarcating landslide vulnerable zones using remote sensing and Geographic Information System (GIS) techniques. Udhampur town lies between 32°34' & 39° 30' North latitudes and 74°16'& 75°38' East longitudes and is covered by parts of Survey of India degree-sheet numbers 43O, 43K, 43P and 43L. The district has a total geographical area of 4540 sq km. The main triggering factors of landslides in the study region are rainfall, slope, soil, land use and manmade activities. The average annual rainfall of this region is about 1300mm. The entire study area is occupied by charnockites with smaller intrusions of dolerite dykes. Two third of the study is covered with sandy loam soil and the remaining by clay loam soil. The most partsof the study area are falling under the categories of gentle and moderate slope (2º to 15º). Land use / land cover maps for the years 2019 and 2020 were prepared from Landsat TM and IRS Resourcesat-2 satellite imageries respectively. Supervised classification technique was used to prepare land use / land cover maps from the satellite data. The land use / land cover maps of 2019 and 2020 were compared and integrated using GIS to carry out the change detection analysis. The change detection matrix was also prepared using GIS to understand the changes occurred in each land use/ land cover category. The analysis indicates that there is a huge transformation of forest land into agricultural land from 2019 to 2020. Minor changes have occurred in the other land use / land cover categories also. Soil samples and core samples were also collected in the field during field visits, and the samples were tested in the laboratory for various engineering properties. Compaction and direct shear tests were carried out to assess the strength characteristics of soils. Sieve and hydrometer analyses were done to know the percentage of sand, silt and clay in soil samples. Liquid limit, plastic limit and plasticity index were also calculated for the samples. XRF and XRD studies were done to know the composition and mineralogy of the soil samples. As number of landslides occurred around Udhampur were studied for preparing landslide vulnerability zonation map. The past landslide details were also collectedand the landslide scar map of

the study area was prepared using GIS. To prepare landslide vulnerability zonation map, various themes such as geology, soil, rainfall, drainage, groundwater level, geomorphology, land use and slope were considered. For the above mentioned nine themes, the thematic maps were prepared from satellite imageries using GIS with the support of Survey of India toposheets. Weightages were assigned to the above nine themes, and also ranks were assigned to the sub-parameters in each theme. Finally the landslide vulnerability zonation maps for Udhampur were prepared separately by integrating all the thematic layers using GIS. The landslide vulnerability map of Udhampur shows that the north-eastern and south-western parts of the vulnerable to landslides than the other parts. This is also crosschecked using the previous landslide records. The landslide scar map which was finally placed over the vulnerability zonation map exhibits perfect matching. This shows the accuracy of the weights and ranks assigned to various themes.

INTRODUCTION

Landslide is a common natural hazard that frequently occurs in hilly regions. Rapid town development, high traffic intensity, and extension of the road from a single lane to double lanes have accentuated the phenomenon of landslides to a great extent in the recent earlier period. Landslides or slope failures are usually not the result of one factor. These are complex phenomena, whose time–space distribution results from an interaction of numerous factors such as geological, geomorphological, physical, and human. Landslides can be triggered by rainfall, earthquake, volcanic activity, and changes in groundwater or disturbance of a slope (mining, quarrying, construction, and vertical cuttings) by man-made activities or any combination of these factors. Mountainous terrain has been generally subjected to slope failure under the influence of various contributing factors. Rapid growth of human population and their activities such as deforestation, infrastructure development and expansion in built-up area is increasing the frequency and magnitude of slope failures. Landslide hazard zonation is the demarcation of areas on the land surface and ranking of landslide prone areas as per the degree of vulnerability from the landslide or other mass movements on the slopes. In general, landslide hazards cannot be completely prevented but the impact of the hazard can be minimized if the problem is predicted before any type development activity.

Role of GIS (Geographic Information System)

Computer aided system for managing the spatial data

Geographic- data items are known or can be calculated in terms of geographic coordinates (X, Y, and Z).

Information - data in GIS are organized to yield useful knowledge, often as coloured maps and images, but also as statistical graphics, tables and various on – screen responses for interactive queries.

System - a GIS is made up from various various interrelated interrelated and linked components with different functions.

Thus, GIS have the functional capabilities for data –

- Capture, input, manipulation, transformation, visualization, combination, query, analysis, modeling and output.
- capable of handling large number of data for analysis

Study area and its environmental condition

The town Udhampur, headquarter of the district has been named after Raja Udham Singh, the eldest son of Maharaja Gulab Singh, the founder of Dogra rule in the state of Jammu and Kashmir. Udhampur district is situated in south eastern part of Jammu and Kashmir state and is bounded in the west by Rajauri district, in the north by Anantnag district, in the north east by Doda district, in the south east by Kathua district and in south west by Jammu district. The district headquarter at Udhampur town lies between 32°34' & 39° 30' North latitudes and 74°16' & 75°38' East longitudes and is covered by parts of Survey of India degree-sheet numbers 43O, 43K, 43P and 43L. The district has a total geographical area of 4540 sq km. In 2007, Udhampur district has been bifurcated into Reasi and Udhampur districts. The areas of Reasi district and Udhampur district were reduced. This booklet discusses the general ground water information of old Udhampur district. The National Highway NH-IA connects the area with the rest of the country (Plate I). All tehsil and block headquarters of the district are well connected by roads. The district is divided in to 5 tehsils (Udhampur, Ramnagar, Chenani, Reasi and Gool Gulabgarh) and 07 blocks, 204 panchayats and 602 villages. There are 8 towns in the district Udhampur viz. Chenani, Katra, Ramnagar, Reasi, Rehamble and Udhampur. The district has the distinction of having holi mata Vaishno Devi Shrine. Patnitop and Kud are the summer hill resorts of the district where as the lake viz. Mansar Lake enhances the beauty of the district. Due to variation in altitude from 600 to 3,000 meters above mean sea level. There is a wide variation in climatic conditions in different

parts of the district experiencing a typical temperate climate in high altitude which experience snowfall and cold winter whereas tropical climate at low altitude. The summer season starts from April to June followed by rainy season from July to September. The October and November although generally dry andmost pleasant season of the year. The winter season begins from December and ends in March. The high altitude areas experience very cold winter and mild summer. The temperature in the snowfall zone varies between sub-zeros to about 35°C. Sub-tropical climate prevails in the low altitude area where there is cold winter but scorching summers. InUdhampur, temperature rises continuously after January and May is the hottest month (max. 42°C, min. 23°C) and January is coldest month (max. 17.4°C and min 2.8°C) of the year. Normal annual rainfall at Udhampur is 1400 mm. Mostly rainfall (~70% of the total annual rainfall) is received from southwest monsoon. The monsoon usually arrives in the first week of July and remains active up to September. Rainfall is also received during winter season due to western disturbances. Monthly rainfall of Udhampur district for the year of 2010 is plotted on graph given below.

METHODOLOGY

The spatial datasets used for the study are satellite imagery, open street map dataset, rainfall data from the Indian Meteorological Department, topographic sheets from Survey of India and the tools used for this study are digital elevation model (DEM) and ISRO Bhuvan web map services. The datasets thus obtained are used in the processing of the landslide hazard zonation map.

DATA COLLECTION

Top sheet

Top sheets of 1:50,000 scales such as 58A/11 and A/15 were collected from Survey of India (SOI, 1973 and 1974) to prepare thematic maps such as base map, elevation contour map and drainage map.

Rainfall

The daily rainfall data of ten years (2004 to 2013) were collected from the Public Works Department (PWD), Govt. of JK. Spatial variation and average seasonal rainfall like post-monsoon (January and February), pre-monsoon (March, April and May), southwest monsoon (June, July, August and September), and northeast monsoon (October, November and December) were analyzed using GIS.

Groundwater level

Data pertaining to monthly groundwater level over a period of ten years from 2004 to 2013 were collected from Groundwater division, Public Works Department, Government of JK, for six controlled

wells in this region. The soil samples and core samples were also collected in the field for laboratory studies.

Geology and Soil

District geology map was collected from Geological Survey of India (GSI) and the district soil map was collected from Soil Survey of India. From the district maps, geology map and soil map of the study area were prepared using GIS.

Satellite Data Products

Resourcesat-2 (March, 2012) LISS IV MX (path 102 row 065-D) with the spatial resolution of 5.8m, and Landsat TM data of 1999 with the spectral bands 0.52-0.59 (B2), 0.62-0.68 (B3) and 0.77-0.86 (B4) were used in this study. The satellite data was registered with reference to Survey of India (SOI) top sheets on 1:50,000 scale in the ERDAS image processing (ver. 9.2) software.

VULNERABILITY

Drainage Pattern and Slope

The drainage pattern observed in watershed is mainly dendritic in nature. The drainage is influenced mainly by the joint patterns and the foliation trends of the rocks. Some streams have straight courses. The stream courses follow the fracture patterns of the underlying rocks. Drainage map shows that the first order streams are high in the northwestern part of the watershed. It is understood that it is an elevated area and the erosion rate is more. There are two water bodies that exist in the southeast part of the study area. Due to high erosion rate, siltation is more in these water bodies. Hence, the silt monitoring station is also located in this region. Prolonged rainfall will increase infiltration and create a saturated soil which reduces shear strength thus it leads to slope failure. Besides the presence of water in the soil or rock supplements the overall weight of the slope, which increases the shear forces causes the slope to be less stable (Kanungo et al 2009).

Geology and soil characteristics

Landslides are responsible for rapid landscape evolution and represent serious hazard in many areas of the world (Varnes 1977, Cendrero & Dramis 1996). Block faulting resulted in the upliftment of the plateau. Due to these tectonic activities the deep-seated metamorphic rocks have undergone considerable deformation during Precambrian times, which resulted in different structural features such as folds, faults and joints. The watershed exhibits thick soil cover in many places. The soil of the area falls under two major types: (1) clayey soil and (2) loamy soil. Only a small area in the northwestern

part consists of loamy soil and the remaining whole area is covered with clayey soil. The depth of the soil usually varies from one to three feet and that of the sub-soil from 10 to 14 feet. The sub-soil is invariably porous. Slope is a geo-dynamic process that naturally shapes up the geomorphology of the earth. However they are a major concern when those unstable slopes wold have an effect of the safety of the people and property (Glade et al 2000). The district is covered partly by Pir Panjal ranges and partly by Outer Himalayas. The altitude of Udhampur district varies from 600 to 3000 meters above mean sea level. The gentle terrain occurs in southern and southwestern part while in northern part is covered by complex and high mountainous terrain.

Land Use / Land Cover Pattern

Landslides are dominantly influence by rainfall, slope, road cutting, land use and many other factors (Pradeep Kishore et al 2012). The land use / land cover exerts a control over landslides and is considered next to slope in importance. While urban activities result in the modification of slope due to leveling of the terrain forming steep cut, modification for agriculture enables the percolation of water particularly in areas wherein vegetables are grown. As a result high frequency was arrived for the class crop lands. The land use factor has been classified as forest plantation, plantations, croplands, built up and water bodies. Land with vegetable crops form the dominant land use followed by forest plantation, settlement, dense forest, mixed cultivation and water bodies. The highest ratio is noticed in vegetable crops as the field is prepared for cultivation loosening the soil for aeration. Further, periodical tilling is carried out to remove the weeds and to aerate the land. The ground is hence, devoid of vegetation growth except for the cultivated crops. This enables percolation of water during rains and the pore pressure of clay bearingsoil increases. The susceptibility for landslides increases manifold where tubers like potato, turnip, carrot, and beetroot are cultivated. Settlements and gardens rank next in the susceptibility followed by forest plantations. Contrary to expectations, forests also record landslides. When the planters converted large tracts of forests into estates, they have left only the steep slopes as forests which have difficulty for accessibility. Thus forests exist only in the steep slopes.

IRRIGATION

The net area irrigated (2009-10) by different source is 50.43 sq.km, out of this, area irrigatedby canals is 48.07 sq.km, by tank is 0.07 sq.km and other sources is 2.29 sq.km.

CROPS

Maize, Wheat and Paddy are the principal crops of the district. Maize is harvested in Kharif season whereas wheat in Rabi season.

Drainage Density

Drainage is a major factor that contributes to landslide in hill areas. As the distance from the drainage line increases, landslide frequency generally decreases because the seepage of water near the drainage network is more as compare to far away from them, so shear strength is reduced near the drainage network. Terrain modification caused by gully erosion may also influence the initiation of landslide (Dai & Lee 2002). To understand the role of drainage, a drainage map was prepared from topographic map on 1: 50,000 and updated with satellite imageries. The drainage map was overlaid on a grid cover of size 0.50 □ 0.50 km. The number of drainage lines present in each grid was counted to know the drainage density. The study area has been classified into 4 types based on the length of drainage occurred per sq.km.

REFERENCES

[1] A S Banuzaki1 and A K Ayu, –Landslide vulnerability assessment using GIS and remote sensing techniques: a case study from Garut – Tasikmalaya Road‖ IOP Conf. Series: Earth and Environmental Science 622 (2021) 012005

[2] C. Sivakami and Dr. R. Rajkumar, ― Landslide Vulnerability Zone by Weights of Evidence Model using Remote Sensing and GIS, in Kodaikanal Taluk (Tamilnadu, India)‖ International Journal of Engineering Research & Technology (IJERT) Vol. 9 Issue 02, February-2020

[3] Shri M. Somorjit Singh, –Remote Sensing & GIS Applications in Landslide Management: Focus North East India‖ North Eastern Conference on Earthquake & Landslide Mitigation, Shillong, 30th April 2018

[4] Jishnu E S, Ajith Joseph K, Sreenal Sreedhar, George Basil, –Hazard Mapping of Landslide Vulnerable Zones in a Rainfed Region of Southern Peninsular India- A Geospatial Perspective‖ International Research Journal of Engineering and Technology (IRJET) Volume: 04 Issue: 07 | July -2017

[5] Krishan Chand and D.D. Sharma, –Spatial Pattern of Landslide Vulnerability at Block Level in District Mandi of Himachal Pradesh: A GIS Based Approach‖ SGVU J CLIM CHANGE WATER Vol. 4, 2017 pp.56-68 ISSN: 2347-7741

[6] D A P Sari1, S Innaqa and Safrilah, –Hazard, Vulnerability and Capacity Mapping for Landslides Risk Analysis using Geographic Information System (GIS)‖ International Conference on Innovative Research 209 (2017) 012106

[7] Elizabeth Aipe Michael and Sailesh Samanta, –Landslide vulnerability mapping (LVM) using weighted linear combination (WLC) model through remote sensing and GIS techniques‖ Model. Earth Syst. Environ. (2016) 2:88

[8] Reshma Raskar-Phule, Deepankar Choudhury, –Vulnerability Mapping for Disaster Assessment using ArcGIS Tools and techniques for Mumbai City, India‖ 16th Esri India User Conference 2015

[9] KIROSO S. M., –Remote Sensing and GIS Usage in Mapping Vulnerable Landslide Areas in Murang'a County, Kenya‖ Department of Geology and the School of Physical Sciences APRIL, 2015

[10]T. Subramani1, S.Sekar, C.Kathirvel, C. T.Sivakumar, ― Geomatics Based Landslide Vulnerability Zonation Mapping - Parts Of Nilgiri District, Tamil Nadu, India‖ International Journal of Engineering Research and Applications Vol. 4, Issue 12(Part 3), December 2014, pp.139-149.

[11] Arunkumar. M, Gurugnanarn. B, Venkatraman. AT.V.R,–Topographic Data Base For Landslides Assessment using GIS In Between Mettupalayam- Udhagamandalam Highway, South India‖ International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-2 Issue-5, April 2013

[12] M. Kannan & E. Saranathan & R. Anabalagan, –Landslide vulnerability mapping using frequency ratio model: a geospatial approach in Bodi-Bodimettu Ghat section, Theni district,Tamil Nadu, India‖ Arabian Journal of Geosciences ISSN, 14 December 2011, 1866-7511.

[13] L. P. Sharma, Nilanchal Patel, P. Debnath & M. K. Ghose, –Assessing landslide vulnerability from soil characteristics—a GIS-based analysis‖ Journal of Geosciences · January 2010, 5:789–796.

[14] Oh HJ, Lee S, Soedradjat GM, –Quantitative landslide susceptibility mapping at Pemalang area‖ Indonesia. Environ Earth Sci (2010) 60:1317–1328

[15] Van Westen, C. J., Castellanos, E., Kuriakose, S. L., –Spatial Data for Landslide Susceptibility, Hazard, and Vulnerability Assessment: An Overview‖ Engineering Geology, (2008) 102(3–4): 112–131, doi:10.1016/j

[16] Yiping, H.R. and Beighley, E. –GIS-based regional landslide susceptibility mapping: a case study in southern California‖, Earth Surface Processes and Landforms, (2007) Vol.33, No.3, pp.380–393

[17] Ermini L, Filippo C, Casagli N, –Artificial neural networks applied to landslide susceptibility assessment‖ Geomorphology (2005) 66:327–343

[18] Zezere, J. L., Reis, E., Garcia, R., Oliveira, S., Rodrigues, M. L., Vieira,G. and Ferreira, A.

B. –Integration of spatial and temporal data for the definition of different landslide hazard scenarios in the area north of Lisbon, Portugal‖, Natural Hazards and Earth System Sciences, (2004) Vol.4, pp. 133–146.

[19] Ohlmacher CG, Davis CJ, –Using multiple regression and GIS technology to predict landslide hazard in northeast Kansas‖ USA. Eng Geol (2003) 69:331–343

[20] Dai, F. C., Lee, C. F., –Landslides on Natural Terrain: Physical Characteristics and Susceptibility Mapping in Hong Kong‖ Mountain Research and Development, 22(1): 40–47, doi:http://dx.doi.org/10.1659/0276-4741(2002)022[0040:LONT]2.0.CO;2

[21] Zhou, C.H., Lee, C.F., Li, J. and Xu, Z.W. –On the spatial relationship between landslides and causative factors on Lantau Island, Hong Kong‖, Geomorphology, (2002) Vol. 43, pp. 197–207,

[22] NRSA –Atlas of Landslide Hazard Zonation Mapping in the Himalayas of Uttranchal and Uttar Pradesh states using Remote Sensing and GIS Techniques‖ NRSA, Department of Space, Govt. of India (2001)

[23] Amod Sagar Dhakal, Takaaki Amada, and Masamu Aniya, –Landslide Hazard Mapping and its Evaluation Using GIs: An Investigation of Sampling Schemes for a Grid-Cell Based Quantitative Method" Photogrammetric Engineering & Remote Sensing Vol. 66, No. 8, August 2000, pp. 981-989.

[24] Varnes D.J., –Landslide hazard zonation: a review of principles and practice, Review Report‖ UNESCO Paris, (1984) 1-63.

[25] Sunil Saha, Raju Sarkar, Jagabandhu Roy, Tusar Kanti Hembram, Saroj Acharya, Gautam Thapa5 & Dowchu Drukpa6, –Measuring landslide vulnerability status of Chukha, Bhutan using deep learning algorithms‖ Scintific Report