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LANDSLIDE IDENTIFICATION USING GIS

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ABSTRACT: - *Landslide, the natural disaster causes a severe damage to the life and the property. Many areas of Udhampur are recognized to be prone to frequent landslide in the past. The migration from the early 1960s made the regions populated. However the settlers are poor and living with cultivations as means of livelihood. Landslide like geological phenomenon is a major threat to the life, property and even to the nature. The variability of major influencing parameters may affect the degree of accuracy of the identifying landslide prone areas. Along with the common factors such as Slope, Elevation, Rainfall density, Soil, Land Use Land Cover, Geology, Drainage density, Road density, Lineament density are also incorporated in this paper to estimate the proneness of the landslide. A weight index strategy is applied to the parameters. The parameters are overlayed (Weighted Overlay Analysis) in order to prepare the landslide susceptibilityzonation map of Udhampur. From the analysis, it is estimated that about 10 sq.km. of land ishighly unstable. The water percolating through these fissures can remove the weathered materials or dilute the clay stone intercalated with sandstone producing either slow slip or creep or sudden rockfall as witnessed recently. Mitigation measures have to be taken immediately. In addition, periodic monitoring of the formation and development of ground fissures should be undertaken to avoid any future possible natural hazard or loss of life and property in the region. Landslides can happen when rainfall amount reaches over a particular threshold of ~155, 212, or 290 mm making the slopes almost saturated. Landslides induced by extreme rainfall also depend on the initial water content (antecedent), geological local terrain settingsand regional factors. This means that sudden landslides are mainly caused by rainfallextremes. From this study it is observed that Remote Sensing and GIS technique can be effectively used in the preparation of hazardous zonation maps, which will help planners and engineers to reduce losses of life and properties through prevention and mitigation measurements. The result of the study can help in carrying out the risk assessment and better preparedness for the future Landslide Hazards.*

Index Terms: — *Landslide, Rock fall, Drain Density, Rain fall intensity, Geology, Slope, Elevation*

INTRODUCTION

Landslide identification plays an important role in landslide risk assessment and management. With the advent of the remote sensing technology, landslides can be identified through visual interpretation of both remote sensing images and topographic surfaces. Although the visual interpretation has high identification accuracy, the process is time-consuming and labor- intensive. Hence, automated or semi-automated methods for landslide identification based on remote sensing techniques are highly sought after in recent years. Landslides are among the most common natural hazards and are the most damaging, leading to a variety of human and environmental impacts. Though there are various steps involved in minimization of landslide hazard, there efforts are made to emphasize only landslide hazard zonation mapping. A Landslide Hazard Zonation (LHZ) map depicts division of land surface intozones of varying degree of stability based on the estimated significance of the causative factors in inducing instability. The LHZ maps have an important role in planning and implementation of development schemes in mountainous areas [1]. Landslide is the result ofa wide variety of processes which include geological, geomorphologic and meteorological factors. The main factors which influence land sliding are discussed by Vanes [2] andHutchinson [3]. Normally, the most important factors are bedrock geology (lithology, structure and degree of weathering), geomorphology (slope gradient, aspect, and relative relief), soil (depth, structure, permeability, and porosity), land use and land cover, and hydrologic conditions. Landslides are triggered by many causative factors. Most landslide- triggering factors can be divided into four main categories including geological, hydrological, topographical factors and loading conditions. Landslide hazard is a particular case of natural hazard defined as ―the probability of occurrence within a specified period of time and within a given area of a potentially damaging phenomenon‖[2]. The present paper deals with thematic data layer generation and their spatial analysis in GIS environment for landslide hazard zonation mapping along NH-1A-Udhampur to Banihal. This zone is known among the most landslides sensitive zones in the world. The major objectives of the study are 1) to prepare various thematic layers including lithology, geomorphology, lineament, fault, percent slope, slope morphology, slope aspect, drainage, landslide incidence, soil texture, soil depth, rock weathering, slope-dip relation, landuse/landcover from various sources in GIS domain; 2) to collect detailed field information about major landslides and soilsof the area in order to generate a soil & terrain information system. GIS layer generation of allthe thematic maps and their integration using ArcGIS software and 3) to prepare landslide hazardzonation maps through the integration of various thematic maps using Landslide Information System (LIS) software based GIS environment and to prepare landslide hazard management maps.

Although efforts have been made to develop efficient landslide identification methods, several problems remain unsolved concerning the application of machine learning and deep learning towards landslide identification:

(1)Current studies mainly focus on identifying landslides with available optical images. The identification of relict landslides is barely explored.

(2)The literature pays more attention to the identification process itself; the impacts of different landslide types on identification performance remain unclear.

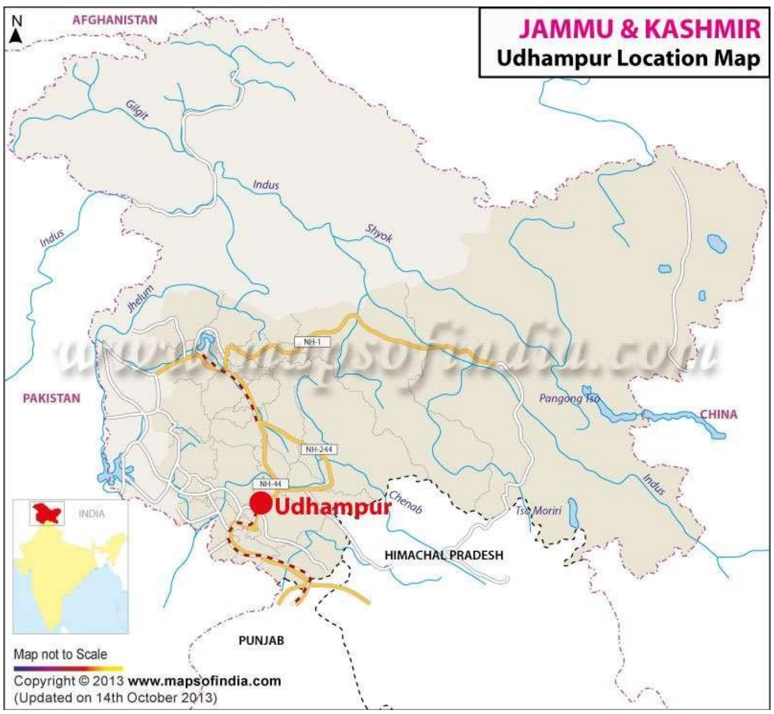
(3)The literature relies heavily on the optical remote sensing images to conduct landslide identification. The latest high-resolution DTM can precisely capture minor terrain differences; yet the potential of DTM-dominant landslide identification using machine learning and deep learning has not been exploited.

The first geographical information systems (GIS) were developed 40 years ago by governmental agencies to handle substantial amounts of spatial data in Canada (Land Inventory CGIS, head manager R.G. Tomlinson) and in the State agencies of Minnesota and New York (USA). In 1970 the first GIS conference, held by the International Geographical Union (IGU), took place in Ottawa, with only 40 participants; by the late 1970s the IGU inventory comprised more than 600 computer programs with about 80 full GIS systems, as a result of the new availability of microcomputers. Since then, GIS training has been offered in a growing number of university laboratories all over the world. A review of GIS history can be found in many text books equate.

1. A data input sub-system which collects and/or processes spatial data derived from existing maps, remote sensors,

etc.

2. A data storage and retrieval sub-system which organizes the spatial data in a form which permits it to be quickly retrieved by the user for subsequent analysis, as well as permitting a rapid and accurate update and corrections to be made to the spatial database.
3. A data manipulation and analysis sub-system which performs a variety of tasks such as changing the form of the data through user-defined aggregation rules or producing estimates of parameters and constraints for various space–time optimization or simulation models.
4. A data reporting sub-system which is capable of displaying all or part of the original database, as well as manipulated data and the output from spatial models, in tabular or mapform. The creation of these map displays involves what is called digital or computer cartography. This is an area which represents a considerable conceptual extension of traditional cartographic approaches as well as a substantial change in the tools employedin creating the cartographic displays.



RESULTS

Landsat 7 Dataset

Landsat represent the world's longest continuously acquired collection of space based moderate- resolution land remote sensing data. Four decades of imagery provides unique resources for those who work in agriculture, geology, forestry, regional planning, education, mapping and global change research. Landsat images are also invaluable for emergency responses anddisaster relief. In this study, Landsat 7 data of the year (2015) is obtained from the Earth explorer (ref:http://earthexplorer.usgs.gov/). The Landsat 7 has the spatial resolution of 30 meters. The data is used to support a wide range of applications in such areas as global change research, agriculture, forestry, mining, land cover and change detection.

The bands in the Landsat 7 are:

- Band 1 – 30m Blue
- Band 2 – 30m Green
- Band 3 - 30m Red
- Band 4 - 30m Near Infrared
- Band 5 - 30m Shortwave Infrared-1
- Band 6 - 60m Thermal Infrared
- Band 7 - 30m Shortwave Infrared-2

Digital Elevation Model (DEM)

Udhampur [32_55.518' N, 75_8.114' E; 750 m above sea level (asl)] is one of the largest districts of Jammu and Kashmir and has a total geographical area of 4540 km2; however, in 2007 the district was divided into two separate districts, i.e. Udhampur and Resai. Physiographically, the area is characterised by mountain ranges trending in a NW–SE direction, deep narrow valleys and terraces, and valley fill deposits with gentle slopes. The district of Udhampur is covered partly by the Pir Panjal ranges and partly by Tertiary rocks (Murree and Siwalik groups of rocks) of the Outer Himalaya. The area is located at an altitude that varies from 600 to 3000 m asl (Nelofar & Bhagat 2014; CGWB, NWHR, JAMMU, 2014). The hilly terrain that exists in the northern and eastern part of the area varies in elevation from 1100 m to 2400 m asl and is characterised by winter nowfall. SRTM DEM for Udhampur with highest resolution of 8425m and the lowest resolution of 223m.

Bhuvan Dataset

The lineaments of the land cover region are extracted from the Bhuvan Web Map Services bycalling it upon in the QGIS software. The extracted lineaments are for the year 2009.

Specification:

Bhuvan – it's a geoportal of Indian Space Research Organization showcasing Indian Imaging Capabilities in multi-sensor, Multi-platform and Multi-temporal domain. This earth browser gives a gateway to explore and discover virtual earth in 3D space with specific emphasis on Indian region.

- Bhuvan evinces Indian Imaging capabilities.
- Portrays Rich Thematic Information towards Societal applications.
- Experience Open Geospatial Consortium (OGC) web services enabling interoperability.
- Robust Application Program Interface (API) for ease of development and integration.
- Interactive 3D modelling and guided tours.

Web Map Services (WMS) – A WMS is a standard protocol for serving dereferenced map images over the internet that are generated by a map server using data from a GIS database. Sever agencies use WMS services, as they make accessing the data quick and easy. WMS services can save time by eliminating the need to download large amount of data, and upload it into your GIS software. Figure 3.2 illustrates the structure of the WMS architecture.

Open Street Map Dataset

Open Street Map, is the project that creates and distributes free geographic data for the world. Open Street Map represents physical features on the ground (e.g. Roads or Buildings) using tagsattached to its basic data structures (its nodes, ways and relations). Each tag describes ageographic attribute of the feature being shown by that node, way or relation. Open Street Map's free tagging system allows the map to include an unlimited number of attributes describing each feature. These features can be accessed, analyzed and can modify. In the present study, Road data for the preparation of hazard zones is extracted from this OpenStreet Map using the QGIS software.

SOI Toposheets

The Survey of India is India's central engineering agency in charge of mapping and surveying. Set up in 1767 to help consolidate the territories of the British East India Company, it's one of the oldest Engineering Department of the Government of India. Dedicates itself to the advancement of theory, practices, collection and applications of geospatial data, and promotes an active exchange of information, ideas, and technological innovations amongst the data producers and users who will get access to such data of highest possible resolution in the near real-time environment. The Geology of the study is extracted from the SOI toposheet of scale 1: 50,000 and the Soil datais extracted from the SOI toposheet of scale 1: 250,000.

IMD Rainfall Dataset

The Rainfall data of 2020 of Udhampur were collected from the Indian Meteorological Department and processed using the GIS software for the preparation of landslide hazard zonation map.

Software Used

- **QGIS: -** it is used for the extraction of Lineaments and Roads.
- **ArcGIS 10.3:-** it is used for the digitization of the parameters like LULC, Drainage...etc., theiranalysis and various map generation.
- **Band 7 -** 15m Panchromatic, The obtained dataset is used in the extraction of the parameters like Land Use Land Cover and the Drainage.

Mapped Landslide Hazard Zones

Overlay analysis is a multi-criteria analysis wherein analysis can be carried out with complex things for finding out certain theme with the help of assignment of rank to the individual class of feature and then assigning weightage to the individual feature considering its influence over theme. All the thematic maps were converted into raster format and superimposed by weighted overlay analysis, which consists of rank and weightage wise thematic maps and integration of them through GIS. Integration of thematic maps for carrying out multi-criteria or overlay analysis in GIS environment was done using ArcGIS software.

Sr. No.	Parameters	Classes	Rank	Weightage (%)
		< 5 %	1	
		5 to 10 %	2	
		10 to 15 %	3	
		15 to 30 %	4	
		30 to 70 %	5	
		500 to 750 m	1	10
		750 to 1250 m	2	
		1250 to 1500 m	3	
		1500 to 1750 m	4	
		1750 to 2250 m	5	
		1400 mm	1	
		1800 mm	2	
		1900 mm	3	
		2600 mm	4	
		3400 mm	5	
		0.05 to 0.2	1	
		0.2 to 0.3	2	
		0.3 to 0.4	3	
		0.4 to 0.5	4	
		0.5 to 0.7	5	
5	LULC	Forest Plantation	1	18
		Agricultural Plantation	1	
		Current Fallow	4	
		Perennial	2	
		Kharif Crop	3	
		Dense/ Closed	2	
		Build up Area (rural)	5	
		Temperate/ sub- tropical	2	
		Dense Scrub	4	
		Open Scrub	5	
		Agro- Horticulture Plantation	4	
		Two Crop Area	3	
		Dry	4	
		Open	4	
		Forest Blank	5	
		Barren Rocky/Stony Waste	1	
		Commercial	5	
		Inland Man-made	5	
		Industrial	5	
		< 0.02	1	
		0.02 to 0.04	2	
		0.04 to 0.07	3	
		0.07 to 0.15	4	
		0.15 to 0.3	5	

7	Geology	Metamorphic Rocks	3	7
		Plutonic Rocks	2	
		Gravelly Clay	5	
		Clay	4	
		Loam	2	
		< 0.2	1	
		0.2 to 0.6	2	
		0.6 to 1	3	
		1 to 1.7	4	
		1.7 to 3	5	

CONCLUSIONS

[1] The present study suggests that numerous ground fissures developed across the spur and regional hillslope that are parallel to planar weakness at Udhampur and its vicinity.

[2] The landslide was active landslide.

[3] The elevation was 1750m – 2250m then the elevation was critical.

[4] The Lineament density was 1750m – 2250m then the Lineament was critical.

[5] The Rainfall density was 3400 m then the Rainfall was critical.

[6] The Slope was 0.5-0.7 then the Slope was critical.

[7] Furthermore, snowfall and rainfall in the upcoming winter and monsoon seasons will lead to expansion or widening of ground fissures from water seepage and downward gravitational movement, triggering landslides in the region.

[8] The water percolating through these fissures can remove the weathered materials or dilute the clay stone intercalated with sandstone producing either slow slip or creep or sudden rock fall as witnessed recently.

[9] Mitigation measures have to be taken immediately. In addition, periodic monitoring of the formation and development of ground fissures should be undertaken to avoid any future possible natural hazard or loss of life and property in the region.

[10] Landslides can happen when rainfall amount reaches over a particular threshold of ~155, 212, or 290 mm making the slopes almost saturated.

[11] Landslides induced by extreme rainfall also depend on the initial water content (antecedent), geological local terrain settings and regional factors.

[12] Sudden landslides are mainly caused by rainfall extremes.

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