Landslide Hazard Zonation Using Geospatial Technology In Parts Of Kodaikanal Hill Region, Tamilnadu

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Abstract

A methodology for landslide hazard zonation mapping using an integrated remote sensing and GIS approach is presented. Landslides often affect Kodaikanal, a well-known tourist hill resort in south India, The hills in Kodaikanal have a fairly thick weathered overburden that tend to slide during heavy rainfall. Therefore the frequency of landslides in these areas is higher. This study represents the causative factors of the Kodaikanal landslides. Here The landslide inventory map shows that, during the past 10 years, out of 66 landslide incidences, 35 incidences were fallen along the Vatlagundu-Kodaikanal-Palani Ghat roads. Secondly thematic maps were prepared on the various causative factors that is geosystem parameters like geology, lineaments/faults, geomorphology, land use/land cover, drainage system, slope, etc. High resolution Geo-eye satellite data, LANDSAT-TM and ASTER images have been used to generate a few of these thematic maps. To identify the vulnerable areas, the above-mentioned parameters were analyzed in a GIS by assigning appropriate ranks and weights. The result is a landslide hazard zonation map showing regions with varying degrees of vulnerability to landslides. Detailed landslide vulnerability analysis along road corridor. This prepared hazard zonation map will enable to propose and implement suitable mitigating measures, thus preventing loss of life and property in the Kodaikanal hills. An additional study made over landslide vulnerability analysis along road corridor region, using lineament and drainage maps. Though the heavy rainfall is triggering landslides in western-Ghat region, the other causative factors in inducing landslides are anthropogenic activities, geosystem parameters like structure, geomorphology, land use practices, drainage system, etc.

Keywords: Geomorphology, Remote Sensing, Zonation Mapping

I. INTRODUCTION

A. LANDSLIDES AND THEIR SIGNIFICANCE

Landslide is a major geological hazard, which poses serious threat to human population and various other infrastructures like dams, buildings and other structures. The term landslide is used to denote the movement of mass rock, debris or earth down a slope (Zezere, 2004). However, it is possible to reduce the impact of landslides. Thus, regional landslide hazard assessment is becoming an important task for government at local and national level together with the community in order to realize the optimum protection to the community and social assets, economy and environment from possible disasters.

B. ROLE OF GEOSPATIAL TECHNOLOGY

The Landslide Susceptibility Maps identifies the vulnerability of an area to landslide. Nora Tassetti *et al* (2008) states that the automatic classification of remote sensing images provides many useful land use information to combine in a GIS environment. With the increase in efficient digital computing facilities, the digital remote sensing data and their analysis have gained enormous importance. Then the spatial and temporal thematic in formations derived from remote sensing and ground based information need to be integrated for data analysis. With the help of GIS, it is possible to integrate the spatial data of different layers to determine the

influence of the parameters on landslide occurrence. Most importantly greatly aid in the prediction of future landslides occurrences, which is very important to those who reside in areas surrounded by unstable slope. The remote sensing data products such as IRS LISS III AND PAN merged are used to extract terrain information and landslides area as also marked in the images. Different thematic maps such as land use/land cover, Lineament, Geomorphology and drainage map can be prepared from the digitally processed remote sensing data.

II. STUDY AREA

Kodaikanal is a city in the hills of the taluk division of the Dindigul district in the state of Tamilnadu, India. kodaikanal is referred to as the "**Princess of hill stations**". It was established in 1845 as a refuge from the high temperatures and tropical diseases of the plains. the town sits on a plateau above the southern escarpment of the upper **Palni hills** at 2,133 meters (6,998 ft), between the **Parappar and Gundar valleys**. The Average Summer Temperature remains 19.8 °C (67.6 °F), The Average Winter Temperature remains 8.3 °C (46.9 °F) and has Average Rainfall of 1650mm.

A. GHAT ROAD

The Kodaikanal Ghat Road has been designated by the Tamil Nadu State Highway Department as SH-156. It begins at 10°9′10″N 77°41′30″E on the Grand Southern Trunk Road (NH-45), about 8 kilometers west of Batlagundu and ends at Kodaikanal with a length of 56.8 kilometers. Palani Ghat Road starts at Kodaikanal and ends at palani with a length of 65 kms. The road was strengthened at a cost of 6 crore in 2009. A retention wall was later built due to a landslide. In 2010, the road was completely blocked after a major landslide occurred due to heavy rainfall.

C. LOCATION OF THE STUDY AREA:

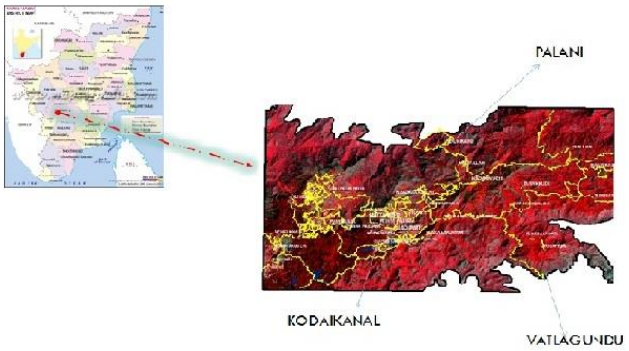

Fig. 1: Study Area

III. METHODOLOGY AND MATERIALS

A. METHODOLOGY:

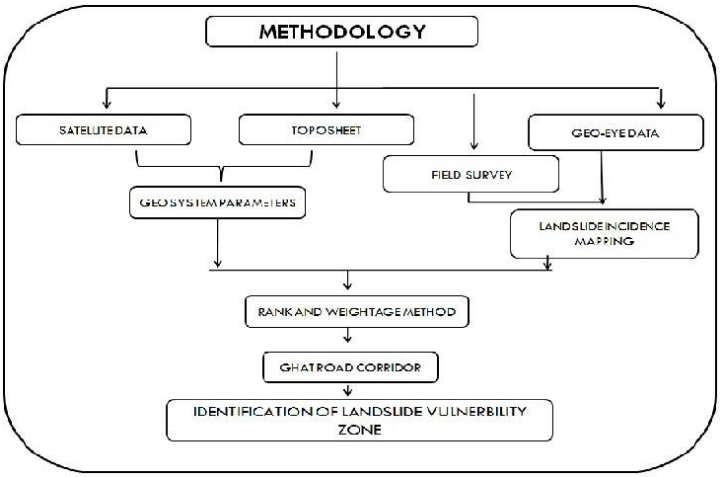

Fig. 1: Methodology Adopted

1) *MATERIALS:*

2) *FIELD DATA COLLECTION AND DATABASE GENERATION:*

Landslide incidences were identified on the field based on landslide remarks and local people's information. And the spatial co-ordinates about landslide incidence was recorded and landslide pictures also taken and to create the database.

Fig. 2: Field Evidences

3) *LANDSLIDE INCIDENCE MAPPING THROUGH GEOEYE DATA:*

The Landslide incidences were mapped through interpretation of Multidated geo eye data by identifying the landslide scars in-between the period of 2004 -2012. There were 34 evident incidences marked and mapped through the comparison of multidated Geoeye data.

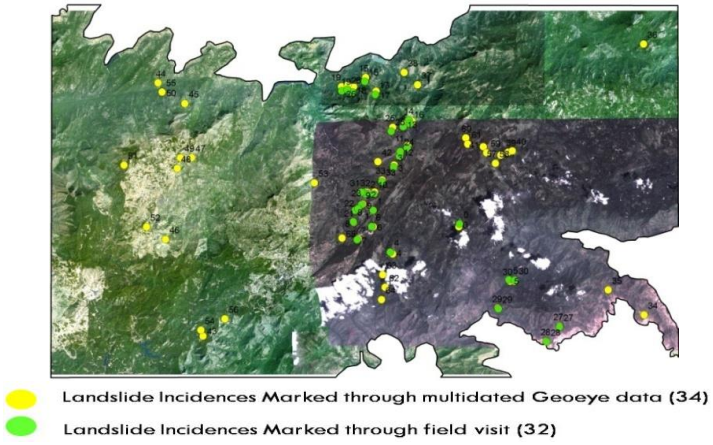

Fig. 3: Geoeye-Data

IV. PREPARATION OF THEMATIC MAPS:

The following thematic maps were prepared for the study area:

- DRAINAGE
- LINEAMENT
- GEOMORPHOLOGY
- LANDUSE AND LANDCOVER
- LITHOLOGY
- SOIL
- SLOPE
- DRAINAGE DENSITY
- LINEAMENT DENSITY

V. WEIGHTAGES GIVEN TO THEMATIC MAPS BASED ON LANDSLIDE INCIDENCES:

Weightages were given to the geosystem parameters based on number of evident landslide occurred in the features of geosystem parameters. Features with high landslide occurrences is given as highest Weightages, similarly remaining features were weighted. Choudhury (1999) states that the consideration of relative importance factors often leads to a better representation of the actual ground situation. The ranks are assigned to each category of the thematic layer. Aparna (2010) states that the determination of

weights of each class is the most crucial in integrated analysis as the output is largely dependent on the assignment of the appropriate weight.

GEOMORPHOLOGICAL FEATURES	**LANDSLIDE INCIDENCES**
DISSECTED PLATEAU	3
HIGHLY DISSECTED PLATEAU	0
MESA	0
BUTTE	0
ESCARPMENT	1
DEBRIS SLOPE	53
BARREN SLOPE	4
BROAD VALLEY FILLED	1
FILLED VALLEY	4
BARREN VALLEY	0
LANDUSE/LANDCOVER FEATURES	LANDSLIDE INCIDENCES
DECIDUOUS FOREST	23
URBAN	0
RURAL	0
PLANTATION	23
SCRUB FOREST	0
EVERGREEN FOREST	10
GRASS LAND	1
BARREN LAND	9
BARREN VALLEY	0
WASTE LAND	0
WATER BODIES	0
SLOPE MAP FEATURES	LANDSLIDE INCIDENCES
VERY STEEP SLOPE	59
STEEP SLOPE	5
MODERATE STEEP SLOPE	2
GENTLE SLOPE	0
SOIL FEATURES	LANDSLIDE INCIDENCE
CLAYEY SOIL ON STEEP SLOPE	42
LOAMY SOIL ON STEEP SLOPE	13
LOAMY SOIL ON GENTLY SLOPE	11
CALCAREOUS CLAYEY SOIL	0
CLAY SOIL ON MODERATELY SLOPING	0
MODERATELY DEEP CLAYEY SOIL ON UNDULATING LANDS	0
DRAINAGE DENSITY CLASS	LANDSLIDE INCIDENCE
MODERATE(0-628.06)	11
HIGH(628.06-1025.84)	22
VERY HIGH(1025.84-2669.29)	33
LINEAMENT DENSITY CLASS	LANDSLIDE INCIDENCE
VERY HIGH	22
HIGH	16
MODERATE	12
LOW	11
VERY LOW	5

Table. 1: Weightages Given To Thematic Maps Based On Landslide Incidences

A. NDVI AND WETNESS:

NDVI VALUE	**LANDSLIDEINCIDENCE**	**NDVI CLASS**
-0.391 – 0.315	7	LOW
0.315 – 0.441	22	HIGH

0.441 – 0.549	27	VERY HIGH
0.549 – 0.757	10	MODERATE
WETNESS VALUE	**LANDSLIDE INCIDENCE**	**WETNESS CLASS**
44.163 – 105.277	5	LOW
105.277 – 123.695	25	VERY HIGH
123.695 – 141.275	22	HIGH
141.275 – 257.643	14	MODERATE

Table. 2: NDVI AND WETNESS

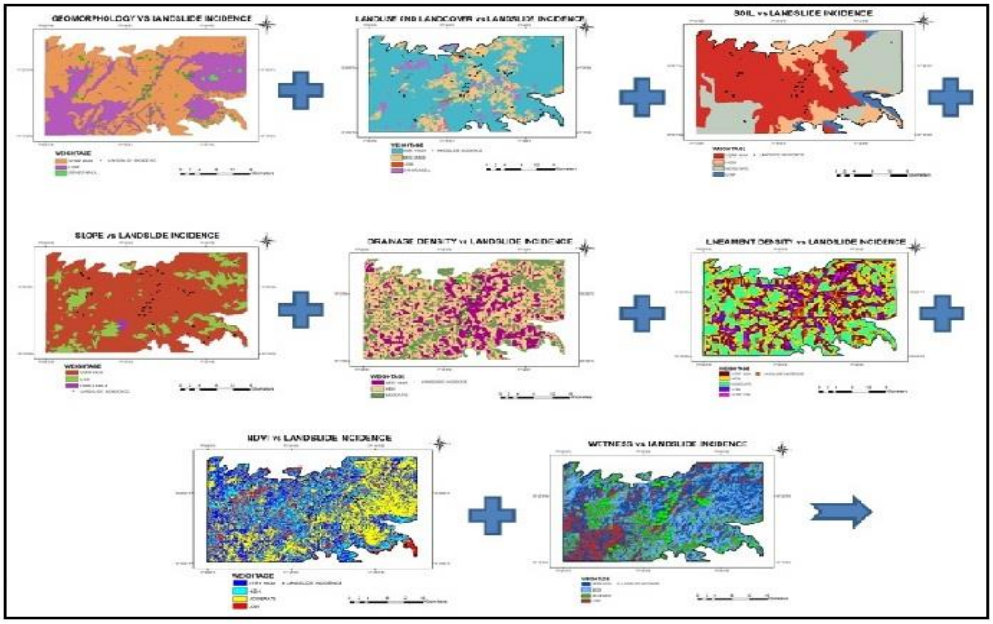

Fig. 4: INTEGRATION OF WEIGHTAGE MAPS

B. LANDSLIDE HAZARD ZONATION MAPPING:

Using raster calculator in GIS environment , the above all weighted maps were integrated and landslide hazard zonation were identified.

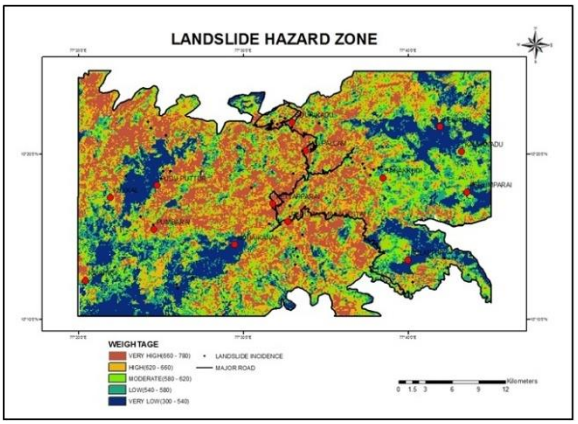

Fig. 5: Landslide Hazard Zonation Map

INTEGRATED	LANDSLIDE INCIDENCE
VERY HIGH(660-780)	24
HIGH(620-660)	19
MODERATE(580-620)	10
LOW(540-580)	7
VERY LOW(300-540)	6

Table. 3: Landslide Hazard Zonation Mapping

VI. DETAILED LANDSLIDE VULNERABILITY ANALYSIS ALONG ROAD CORRIDOR:

For detailed study of landslide vulnerability, we analyzed along the ghat road section. We buffered out 1000m along the road side for our detailed analysis. Among 66 evident landslides , 35 landslides fall under the ghat road buffer zone. Even though the entire buffer zone is vulnerable area ,only some places are subjected to landslides, the reason behind this is major lineaments and major drainages are crossing the ghat road section . Some of the landslides occur along the lineament zone.

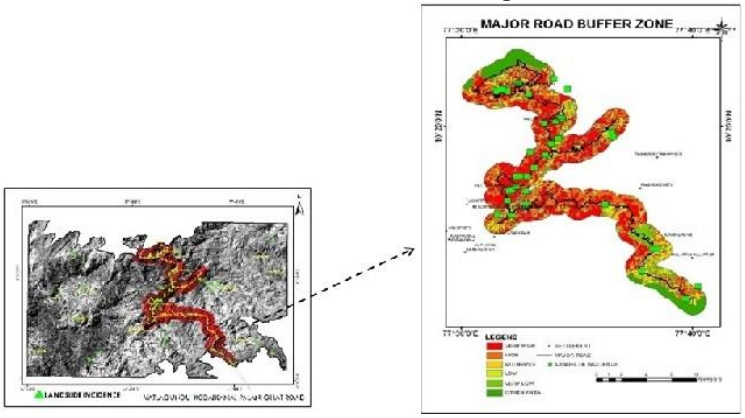

Fig. 6: Lhz In Ghat-Road

A. METHOD AND MAP USED:

Constructing the road in vulnerable zones, Failure associated with soil and rock mass, Linear features of fold, fracture, crack, joints and Drainages are the most important inducing factor for landslide occurrence alone ghat road session. The map indicates the vulnerable zones with and without landslide incidences. Though most of the region are of vulnerable, only some areas are affected and these areas were identified by 3D surface analysis(using ArcScene) with Lineament and Drainage intersection. Still in some vulnerable zones and these lineament and drainages were intersecting and these areas identified as most prone zones for future landslide occurrences.

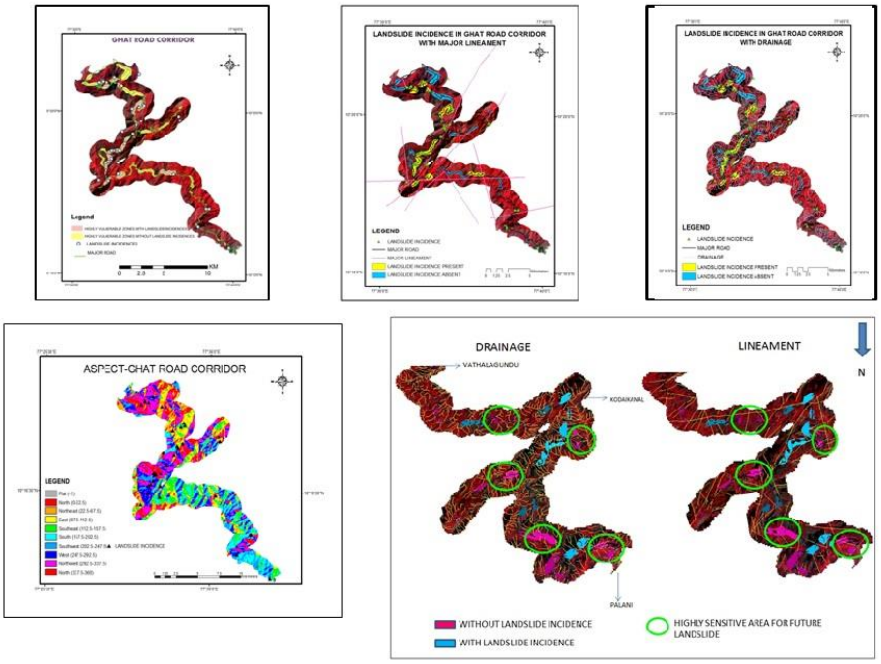

Fig. 7: Future Landslide Sensitive Zones

VII. RESULT AND DISCUSSION:

Landslide is one of the major disasters in hilly region. As far as India is concerned, Himalayan region in the extra peninsular India and Eastern and Western Ghats region in Peninsular India are more prone for landslide. The tectonic movements are generally

attributed to Himalayan landslide and at the same time landslides occurring at Eastern and Western Ghat region are due to the improper developmental activities. The most of the landslides are occurring in Western Ghat region during the monsoon period. From that it can be said that the rainfall is the major triggering parameters in this region. Though the heavy rainfall is triggering landslides in western Ghat region, the other causative factors in inducing landslides are anthropogenic activities, geosystem parameters like structure, geomorphology, land use practices, drainage system, etc. Under the above backdrop, the present study is aimed to identify the what are the various causative factors behind the landslides in parts of Western Ghat region especially in Kodaikanal region.

VIII. CONCLUSION:

At first, detailed landslide inventory mapping was done through the field work and interpreting the high resolution Geo-eye satellite data. The landslide inventory map shows that, during the past 10 years, out of 66 landslide incidences, 35 incidences were fallen along the Batlagundu-Kodaikanal-Palani Ghat roads. Secondly thematic maps were prepared on the various causative factors that is geosystem parameters like geology, lineaments/faults, geomorphology, land use/land cover, drainage system, slope, etc. The international community has acknowledged the significance of geological hazards for natural hazard reduction (Pachauri *et al.*, 1998). Then the landslide incidences were analysed in conjunction with various geosystem parameters and according rank and Weightages were assigned to various sub parameters. The weighted maps on the causative factors were integrated under the GIS environments and from the same landslide hazard zones were identified

REFERENCES

[1] Zezere J L, Reis E, Garcia R, Oliveira S, Rodrigues M L, Vieira G and Ferreira A B, (2004), Integration of spatial and temporal data for the definition of different landslide hazard scenarios in the area north of Lisbon (Portugal) Nat. Haz. And Earth Sys. Sciences 4 133–146.
[2] Panchauri A K, Gupta P V and Chanda R, (1998), Landslide zoning in a part of the Garhwal Himalayas Environmental Geology. 36 325–334.
[3] Nora Tassetti, Annamaria Bernardini and Eva Savina Malinverni, (2008), Use of Remote Sensing Data and GIS technology for assessment of Landslide Hazards in Susa Valley, Italy, DARDUS-Università Politecnica delle Marche, Ancona, Italy
[4] Choudhury, P R, (1999), Integrated remote sensing and GIS techniques for groundwater studies in part of Betwa basin, Unpublished Ph.D. thesis, Department of Earth Sciences, University of Roorkee, India.
[5] Aparna S Bhaskar, (2010), Remote Sensing and GIS Based Studies of Silica-Grade Sand Resources along the Northern Tamil NADU Coat, South India, Published Ph.D. thesis, Department of Geology, Anna University, India.