Global Journal of Science Frontier Research: H
Environment & Earth Science
Volume 16 Issue 4 Version 1.0 Year 2016
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Landslide Hazard Zonation using Quantitative Methods in GIS, Pauri Garhwal District, Uttarakhand, India

By Ramlakhan Yadav & Dr. Neelam Rawat
Almora Kumaun University

Abstract- Landslides are one of the critical natural processes, which cause enormous damage to life and property. These include roads, railways, bridges, dams, houses and also lead to loss of life. Hence, there is a need for landslide hazard zonation for identification of potential landslide areas. The present study is an attempt towards development of a landslide model by using multi-criteria decision analysis in GIS and remote sensing techniques for landslide hazard zonation. Pauri district was selected for this project. ResourceSAT-2 LISS- 4-Mx satellite imageries, SOI topographical maps, and ancillary data were used as inputs to the study. The data layers of Landuse-landcover and Geology were interpreted from satellite image and available ancillary data. Other raster thematic layers i.e. Slope, Aspect, Elevation and Drainage density have been generated in Arc info 3D Analyst Tool using ASTER DEM of 30 m. resolution.

Keywords: pauri garahwal region the landslide hazard zonation, multi- criteria decision analysis quantitative methods in remote sensing and GIS.

GJSFR-H Classification: FOR Code: 961099

LANDSLIDEHAZARDZONATIONUSINGQUANTITATIVEMETHODSINGISPAURIGARHWALDISTRICTUTTARAKHANDINDIA

Strictly as per the compliance and regulations of :

Landslide Hazard Zonation using Quantitative Methods in GIS, Pauri Garhwal District, Uttarakhand, India

Ramlakhan Yadav [α] & Dr. Neelam Rawat [σ]

Abstract- Landslides are one of the critical natural processes, which cause enormous damage to life and property. These include roads, railways, bridges, dams, houses and also lead to loss of life. Hence, there is a need for landslide hazard zonation for identification of potential landslide areas. The present study is an attempt towards development of a landslide model by using multi-criteria decision analysis in GIS and remote sensing techniques for landslide hazard zonation. Pauri district was selected for this project. ResourceSAT-2 LISS- 4-Mx satellite imageries, SOI topographical maps, and ancillary data were used as inputs to the study. The data layers of Landuse-landcover and Geology were interpreted from satellite image and available ancillary data. Other raster thematic layers i.e. Slope, Aspect, Elevation and Drainage density have been generated in Arc info 3D Analyst Tool using ASTER DEM of 30 m. resolution. A numerical rating scheme for the factors was developed for spatial data analysis in GIS. First of all, delineation of landslides (167 Nos.) from high resolution satellite data was carried out and verification from Google Earth data was done. Extraction of relevant parameters was done from the remotely sensed data using digital and visual interpretation techniques. A statistical relationship was established between landslides and selected terrain parameters. Weights were assigned to different layer depending on their impact on occurrence of landslide. Landslide Hazard Zonation map was prepared based on integration of remotely sensed data derived layers and terrain characteristics derived topographic data. Validation of the results was done through ground checks and finally the Landslide Hazard Zonation map and Digital database was created in GIS environment. The resulting landslide hazard zonation map delineates the area into three different zones of relative Hazard (HZ) classes: High, Moderate and Low. 110 landslide fall in the High HZ category while 43 in the Moderate HZ category. 14 landslides fall in the Low HZ category. The High HZ class was located in the Amsaur, Chowki Ghata while Dugadda and Kandikhal falls in moderate HZ class.

Keywords: pauri garahwal region the landslide hazard zonation, multi- criteria decision analysis quantitative methods in remote sensing and GIS.

Author α: M.sc Remote Sensing & GIS Dept. of Geography Kumaun University, S. S. J. Campus, Almora Kumaun University, Naninital Uttarakhand University. e-mail: ramlakhan9918@gmail.com

Author σ: Scientist(SC) Uttarakhand Space Application Center Uttarakhand Dehradun.

I. Introduction

Landslide one of the natural catastrophies, always cause a major problem in the Himalayas by killing hundreds of people every year besides damaging the properties and blocking the communication links. Landslides in the mountainous terrains are natural degradational processes, and one of the most important landscape building factors. Most of the terrains in the mountainous areas have been subjected to slope failure at least one under the influence of a variety of factors, and triggered by event such as extreme rainfall or earthquakes. The frequency and magnitude of slope failures can increase due to human activities, such as deforestation or urban expansion. The problem of landslides becomes more aggravated, especially during the rainy season, through the main causative factor for the stability are often geological and geomorphological in nature. As such there is an urgent need on part of the scientific community to formulate strategies for minimizing the societal impact of landslides. One of the first steps in this direction preparation of Landslide Hazard Zonation (LHZ) maps.

Aim and Scope of the Project

The aim of the project is to operationalise a working methodology wherein a geoenvironmental parameters are analysed to develop models of for mapping landslide prone areas using remotely sensed data, geographical Information System (GIS). Earlier studies have demonstrated the capability of remote sensing based techniques in extraction of landslide related information using visual as well as digital image processing techniques, in which integration of remote sensing derived information with relevant terrain parameters and other ancillary/field data have been made in GIS environment. It is proposed to provide LHZ maps showing the probable areas of landslide occurrence based on geological/geomorphological conditions.

II. Objectives

a) Delineation of landslides from high resolution satellite data and verification from Google Earth data.

b) Extraction of relevant parameters from the remotely sensed data using digital and visual interpretation techniques.
c) Establishing statistical relationship between landslides and selected terrain parameters.
d) Preparation of Landslide Hazard Zonation based on integration of remotely sensed data derived layers and terrain characteristics derived topographic data.
e) Validation of the results through ground checks.
f) Compilation of Landslide Hazard Zonation map and creation of Digital database.

a) Description of the study area

Pauri District lies between Longitudes 78o 11' 30" E and 79o 14' 20" E & Latitudes 29o 26' 45"N and 30o 14' 42"N and falls under Survey of India toposheets Nos. 53J/8, 53K/5, 53J/12, 53K/9, 53K/10, 53J/16, 53K/13, 53K/14,53N/4, 53O/1 and 53O/2. Pauri district forms boundaries with Dehradun & Haridwar in west, Tehri, Rudraprayag and Chamoli in north, Naintal and Almora in east and Bijnor(U.P.) in south. The District is administratively divided into nine tehsils, viz., Pauri, Lansdown, Kotdwar, Thalisain, Dhumakot, Srinagar, Satpuli, Chaubatakhal & Yamkeshwar and fifteen developmental blocks, viz., Bironkhal, Dwarikhal, Dugadda, Ekeshwer, Jaihrikhal, Kaljikhal, Khirsu, Kot, Nainidanda,Pauri, Pabo, Pokhra, Rikhnikhal, Thalisain, Yamkeswar. The area of Pauri district is 5230 sq.kms. The population is 687,271 which are distributed in 3473 villages. Rivers Alaknanda, Purvi Nayar, Hewal, Ramganga, Malan, Sona, Pachhmi Nayar, Gawana Gad, Nawalka, Sukro and Kho drain the district.

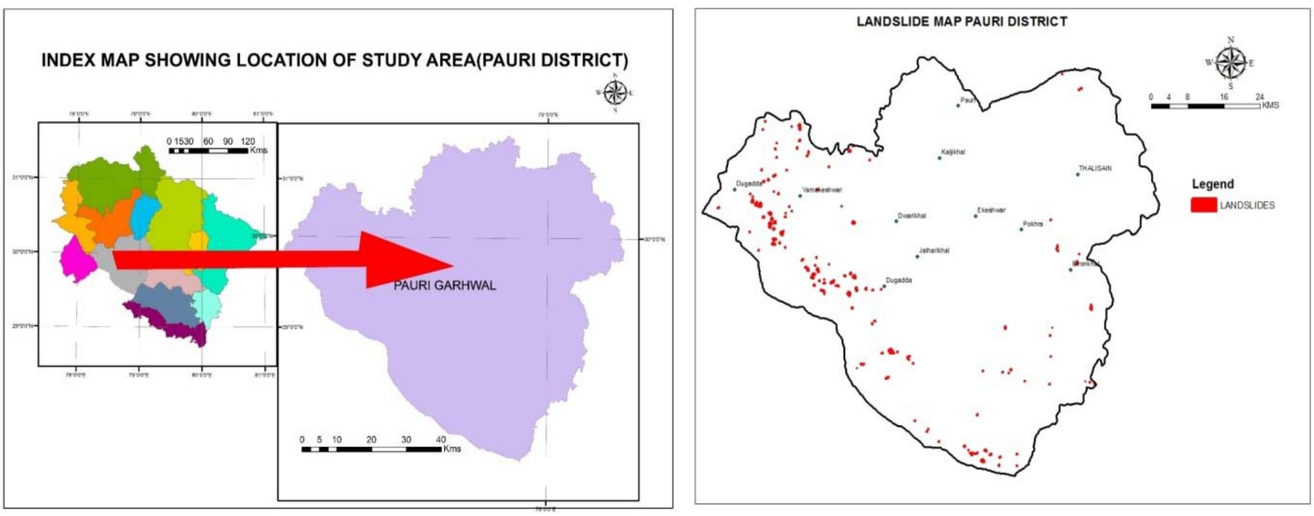

Figure 1

III. Methodology

The satellite data has been georeferenced using the standard coordinate system of the topographic maps using Erdas Imagine software. The georeferenced satellite data is opened in the Arc GIS 10.2.2 Arcview and visual interpretation techniques were used to demarcate the existing landslides. The standard image interpretation keys like tone, colour, texture, association were used. In total 167 landslides have been marked. These landslides were converted to Kmz files and overlaid on the Google Earth software. The locations were verified in the 3 dimensions and checked from all the angles. Based on the objectives and information needs spatial data- consisting of thematic maps prepared form remotely sensed data and other /conventional sources. Geographical Information System (GIS) Package is kept as core of the database. The spatial data domain forms the set of layers prepared form RS as well as from other sources, and the Survey of India (SOI) longitude and latitude coordinate system (depicted on SOI topographical maps). Thus it was imperative to follow the standards of SOI map sheets. the chosen scale for input data is 1/50000.

Flow Chart of the Methodology

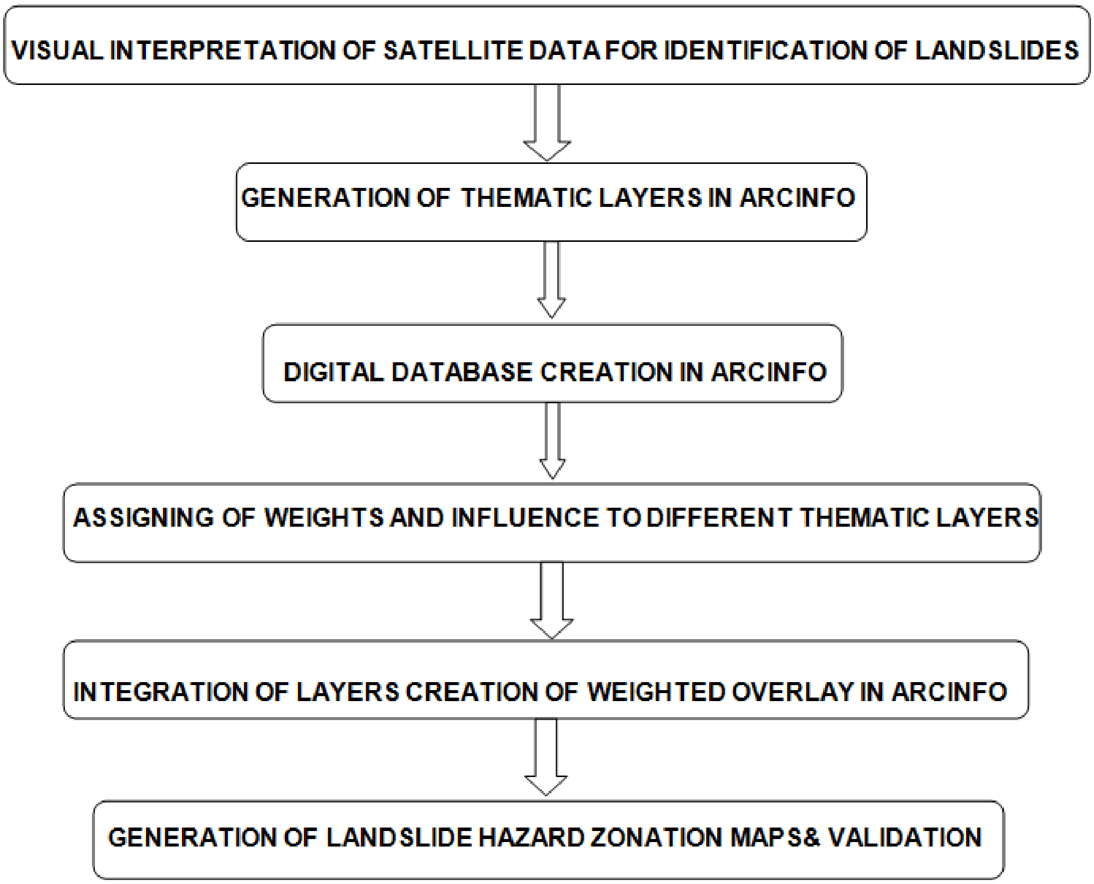

Figure 2

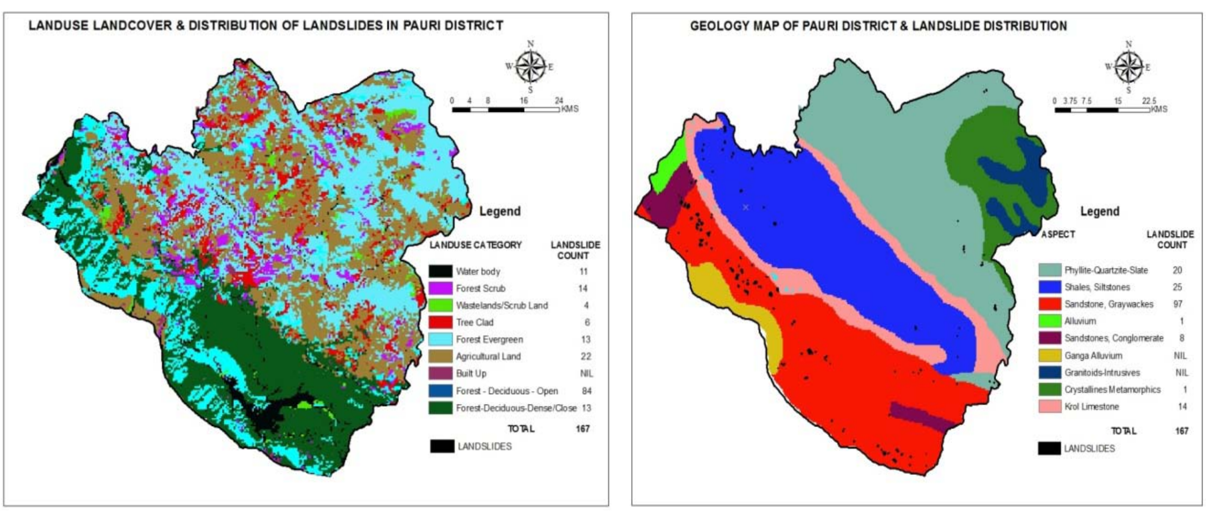

Figure 3

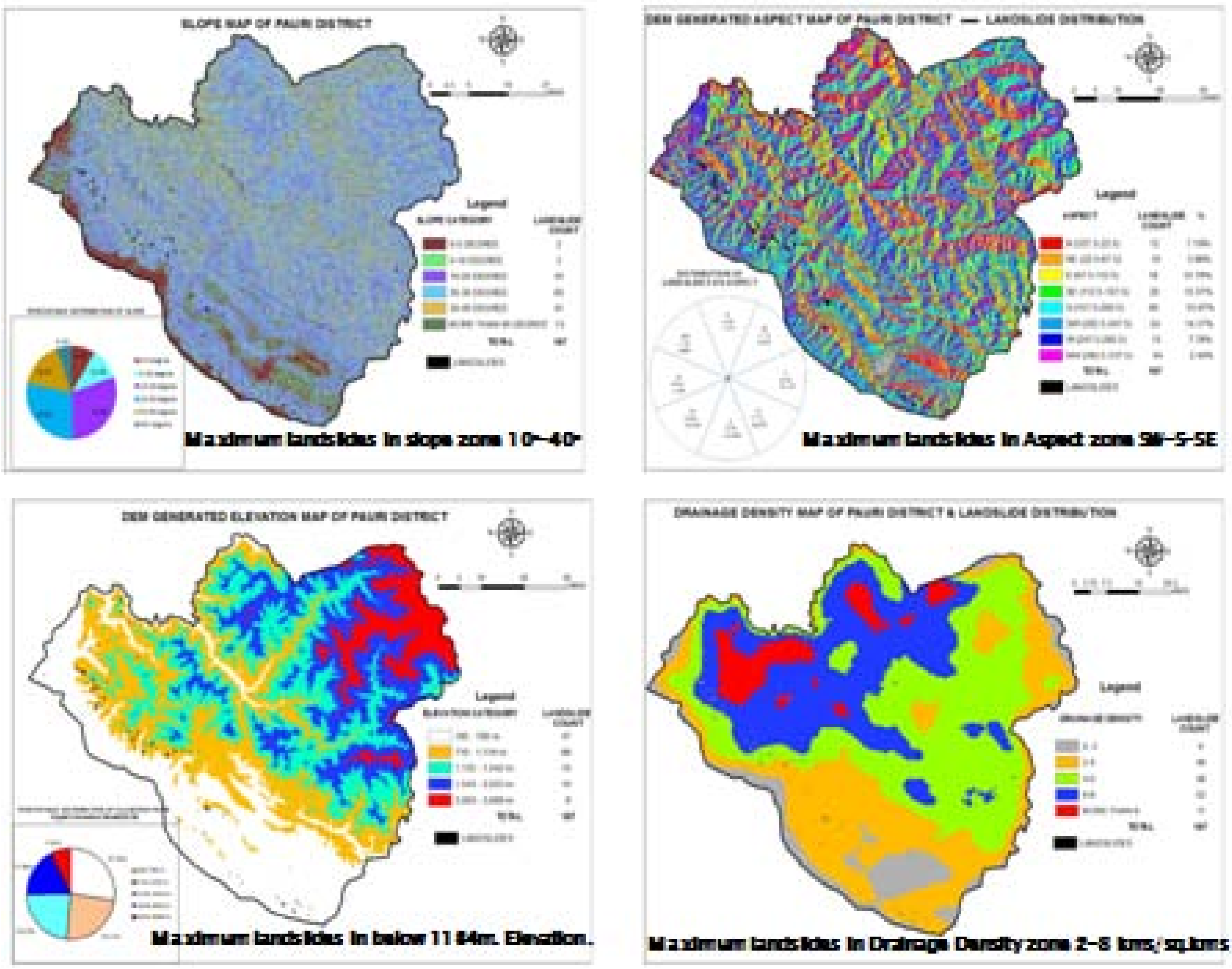

Figure 3

IV. Landslide Mapping

Using High resolution LISS-IV & Cartosat-2A merged data of 2011-12 Landslides were mapped by visual interpretation of satellite image. Total 167 Landslides have identified.

a) *Landslide Hazard Zonation Map*

Base map(Roads, District, Block, Rivers) has been prepared from available data from the centre.

Followingvector thematic layers have been prepared by interpreting satellite image.

Land use/land cover

1. *Geology*

Other raster thematic layers have been generated in Arc info 3D Analyst Tool using from ASTER DEM of 30 m. resolution.

2. *Slope 2.Aspect 3. Elevation*

Drainage density for generation of Landslide Hazard Zonation maps. Thematic maps/layer generated are

b) *Integration Of Maps*

The above 6 layers were integrated in the Weighted Overlay model of ArcInfo and weights were assigned corresponding to landslide occurrence in these layers. The influence of the layer in causing landslide has also assigned. The details are as under

Table 1

Sr. No.	Layer	Influence	Class	Weight
1	Slope(Degrees)	25%	0-5	1
			5-10	2
			10-20	7
			20-30	8
			30-40	6
			40-50	3
2	Aspect(Direction)	9	North	2
			North-East	2
			East	3
			South-East	7
			South	8
			South-West	7
			West	2
			North-West	1
3	Elevation(metre above m.s.l.)	13%	185-709m.	6
			710-1134m.	8
			1135-1542m.	3
			1542-2023m.	2
			2024-3069m.	1
Sr. No.	Layer	Influence	Class	Weight
4	Drainage Density(km/sq. kms)	10%	0-2	2
			2-4	7
			4-6	7
			6-8	8
			More than 8	3
5	Landuse/Landcover	15%	Water Body	2
			Forest Scrub	3
			Wasteland-Scrub	1
			Treeclad	1
			Forest Evergreen	3
			Agriculture	4
			Built up	NIL
			Forest Deciduous Open	8
			Forest Deciduous Dense/Close	3
6	Geology	25%	Phyllites-Quartzites-Slates	7
			Shale-Siltstones	5
			Sandstone-Graywacks	8
			Alluvium	2
			Sandstone-Conglomerate	8
			Ganga Alluvium	1
			Granitoids	3
			Crystallines-Metamorphics	4
			Krol Limestone	6

V. Results and Discussion

The Final Landslide Hazard Zonation map generated after processing 6 themes in Arc Info is as under. The final map has been classified in 3 categories viz. High, Moderate and Low Hazard categories. Geology in order to understand the landslide geomorphology of the study area, general lithological map has been prepared with the help of World View -2 MS satellite imagery (0.46 cm) and Pauri Garhwal in Uttarakhand –Geological survey of India map the study area is located in the lesser Himalaya of Pauri Garhwal Uttarakhand the krol group rocks of the lesser Himalaya,This map has been prepared by integrating 06 layers. More layers need to be added in the model to obtain more precision. This map is not checked in the field ground truth.

a) *Slope map*

Slope is a very important factor in determining the slope stability. Substrate rock characteristics determine the slope stability relationship between the slope, lithology and frequency of landslide is complex many workers have tried to work out this statistically using criteria either individually or cumulatively for examining the slope factors like slope steepness (in

Global Journal of Science Frontier Research (H) Volume XVI Issue IV Version I Year 2016

degrees or per cent) and slope aspect- direction in which a slope face and curvature are considered. Slope map has been generated and classified into 6 slope classes i.e. 0-5o, 5-10o, 10-20o, 20-30o, 30-40o and more than 400. Distribution of landslides in different slope categories is also done. Maximum landslides have occurred.

b) Aspect map

Aspect map has been generated and classified into 8 aspect classes. Distribution of landslides in different slope categories is also done. Maximum landslides have occurred in aspect categories South-West (14.37%), South (35.97%) and South East (15.57%) directions. The Southern aspect(SW-S-SE) contribute for 65.91% of total landslides.

Table 2

Landslides	%	Aspect	Landslides	%
12	7.19	S(157.5-202.5)	60	35.97
10	5.99	SW(202.5-247.5)	24	14.37
18	10.78	W(247.5-292.5)	13	7.78
26	15.57	NW(292.5-337.5)	04	2.40

c) Elevation map

Elevation map of Pauri district was prepared by classifying Digital Elevation model into 5 elevation categories. Distribution of landslides in different elevation categories is also done. Maximum landslides have occurred in elevation category (710-1134m) and (185-709m).

d) Drainage Density map

Drainage density is the total length of all the streams and rivers divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream channels. It is also directly proportional to the magnitude of erosion thus effecting the incidences of landslides. Its unit is kms/sq.kms. Drainage density map has been generated from ASTER DEM using 3D Analyst tool and classified into 6 classes viz. 0-2, 2-4, 4-6, 6-8 and more than 8(kms/sq.kms). Distribution of landslides in different drainage density categories is also done. Maximum landslides have occurred in Drainage Density category 2-4, 4-6 and 6-8(kms/sq.kms).

e) Geology

Lithology plays a very important role in the occurrence of landslides. Interaction between local geology and the long-term climatic conditions result in significantly different landforms with varying degree of susceptibility to land sliding. Geological map of Pauri district has been adopted from Geological map from Geological Survey of India. Rock types Phyllites, Quartzites, Slates, Siltstone, Sandstones, Graywacks, Granitoids, Alluvium, Crystallines & Metamorphics and Limestones are present in the district. Maximum landslides have occurred in Sandstone-Graywacks category (Siwalik formation). The area is also traversed Himalayan Frontal Thrust, Main Boundary Thrust and Ramgarh/North Almora Thrust.

f) Landuse-Landcover

Landuse-Landcover map of Pauri district has been adopted from Landuse-Landcover layer prepared under USAC Project. Classes are Water body, Forest Scrub, Wasteland/Scrub, Treeclad, Forest Evergreen, Agriculture land, Built up, Forest Deciduous Open, Forest Deciduous Dense/Close. Maximum landslides have occurred in Forest Deciduous Open category(84) followed by Agriculture Land(22), Forest Scrub(14), Forest Evergreen & Forest Deciduous Dense/Close(13 each) and Water Body(11).-Landslide hazard zonation map Geology in order to understand the landslide geomorphology of the study area , general lithological map has been prepared with the help of World View -2 MS satellite imagery (0.46 cm) and Pauri Garhwal in Uttarakhand –Geological survey of India map the study area is located in the lesser Himalaya of Pauri Garahwal Uttarakhand the krol group rocks of the lesser Himalaya, This map has been prepared by integrating 06 layers.

Table 3 : The Landslide hazard zonation details as under

Sr. No.	Hazard category	No. of landslides
1	Low	14
2	Moderate	43
3	High	110
4	Total	167

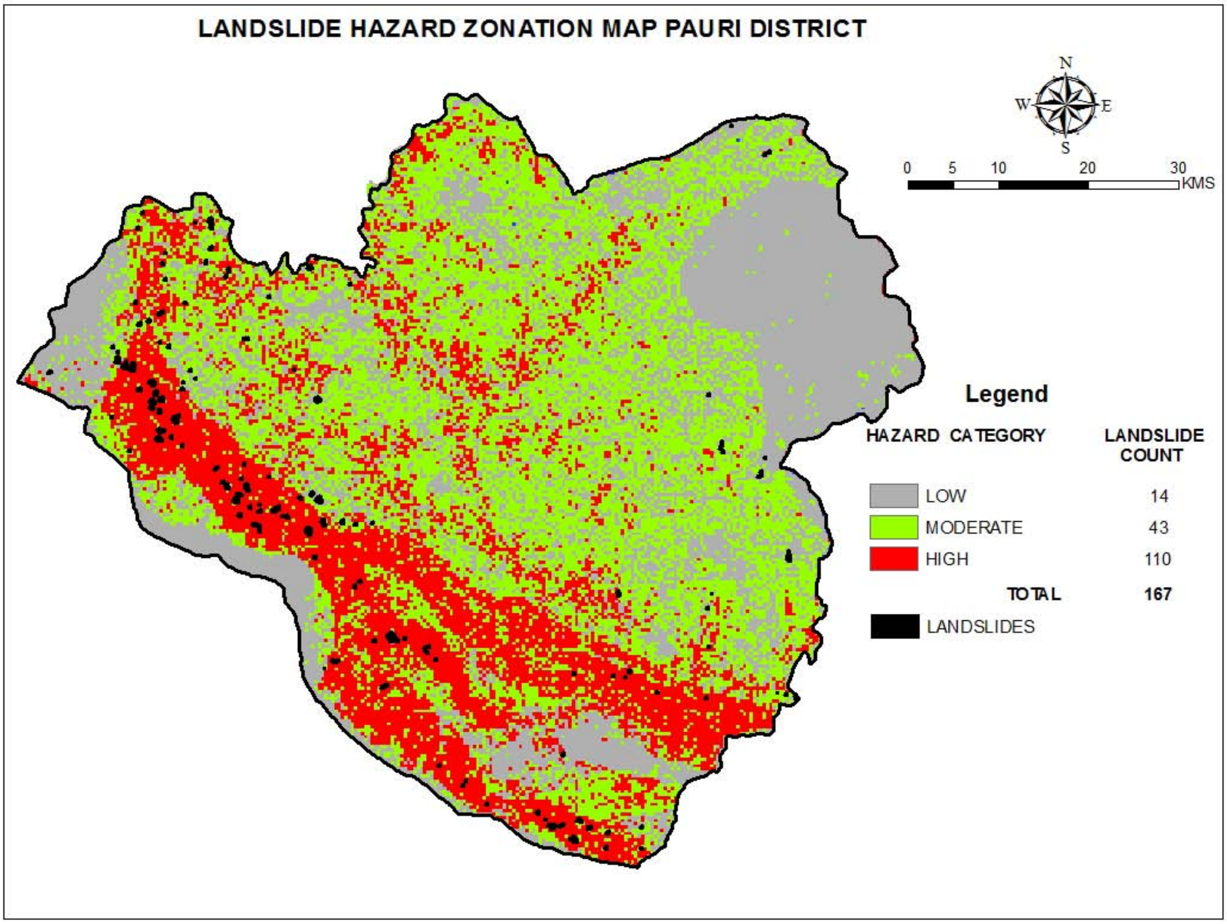

Figure 4

VI. Conclusion

The present study brings out a definite relationship between the Landslide occurrence and the Remote Sensing generated thematic layers. The Landslide Hazard Zonation is categorized in three categories High, Moderate and Low Hazard zones. Out of 167 toal landslides, 110 Landslides fall in the High HZ and 43 Landslides fall in Moderate HZ category while only 14 landslides fall in the Low HZ category. 34.01% of the district falls under Low HZ category and 40.73% falls under Moderate HZ category while 25.26 under High HZ category.

VII. Acknowledgments

The authors are especially thankful to Dr. Durgesh Pant, Director USAC, Dehradun for providing the permission to use USAC lab facilities and satellite datasets for the research work.

References Références Referencias

1. Cruden, D. M., and Varnes, D. J., 1996. Landslide types andprocesses. In: Turner A.K., Schuster R. L., (ed.) Land slide investigation and mitigation special report 247, Transportation Research Board, National Research Council. Washington, DC:National Academy Press, pp.
2. 2006 S. K Investigation of Triggering factors on Landslide Occurrence and landslide Hazard Zonation A GIS Based Approach B.Sc. Thesis Institute of forestry pokhara Kathmandu Nepal.
3. 1996 Cruden D.M. and Varnes, D.J Landslide types and processes. In turns A.K Schuster R.L.(E.D.) landslide investigation and mitigation special report transportation Research board, National Research council. Washington National Academy pres.
4. 2002 Yung A.Y... And pai H.H.Application of remote sensing and GIS in landslide detection International journal of remote sensing.
5. 1988 Yin. K.L and Yan Yan T.Z Statistical prediction model for Slope Instability of Metamorphosed Rocks in Bonnard C (Ed) Proceedings of the 5th International Symposium on landslide.
6. 2008 Sharma M, KUMAR, R GIS – Landslide hazard Zonation a C ASE study from the parwanoo Area lesser and outer Himalaya, H.P.., India Bulletins of Engineering Geology and the Environment.
7. 2007 Choubey, V. M .P.K.Mukherjee, B.S. Bajwa and walia, V. Geological and Tectonic Influence on water –Soil- Radon Relationship in mandi –manali Area Himachal Himalaya Environmental Geology.