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ASSESSMENT OF HIGH ALTITUDE MASS MOVEMENT IN THE PARTS OF ALKNANDA VALLEY

Subtitle:- *Natural Hazards And Disaster Risk Management Indian Space Research Organisation*

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INTRODUCTION

Landslides are more widespread than any other geological event and can occur anywhere in the world. They occur when large masses of soil, rocks, or debris move down a slope due to the effect of a natural phenomenon or human activity. Landslides are one of the major natural disasters that are frequently occurring in the Indian Himalayas causing considerable loss of lives and property every year. In Garhwal Himalaya of Uttarakhand state such landslide disasters occur very frequently. A few examples in the recent past are Malpa landslide in 1998, Phata landslide in 2001, Uttarkashi landslide in 2003, Pithoragarh landslide in 2009 and Bageshwar landslide in 2010. Flash floods due to cloudbursts and breaching of temporary landslide dams in river valleys also occur frequently and one of the most severe one is the recent flash flood along with debris flow at Kedarnath on 16–17 June 2013 claiming more than a thousand casualties. A proper landslide hazard assessment is imperative to minimize such losses.

Figure 1: landslide prone zones in Alaknanda valley (Source: https://timesofindia.indiatimes.com/city/dehradun/uttarakhand-500-landslide-prone-zones-in-alaknanda-valley-finds-study/articleshow/93382266.cms)

Study area

The proposed study was carried out along the Chamoli district, Bhalgaon, Dronagiri, Badrinath and few parts of Arurhi Paruri, Govind Ghat, Joshimath in the upper reaches of Alaknanda valley, Garhwal Himalaya of Uttarakhand State (figure 1). There are numbers of active landslides, which are badly affecting the National Highway and are the potential sites to cause disaster in the event of a major rainfall or earthquake. Alaknanda River is an antecedent gorge, which is deep, narrow and sinuous. The tributaries of Alaknanda River are meeting at high angle and generally flow with great force in steep and narrow channels often resulting in excessive toe erosion. The area receives heavy rainfall during monsoon and experiences winter rain and snowfall during the winter season.

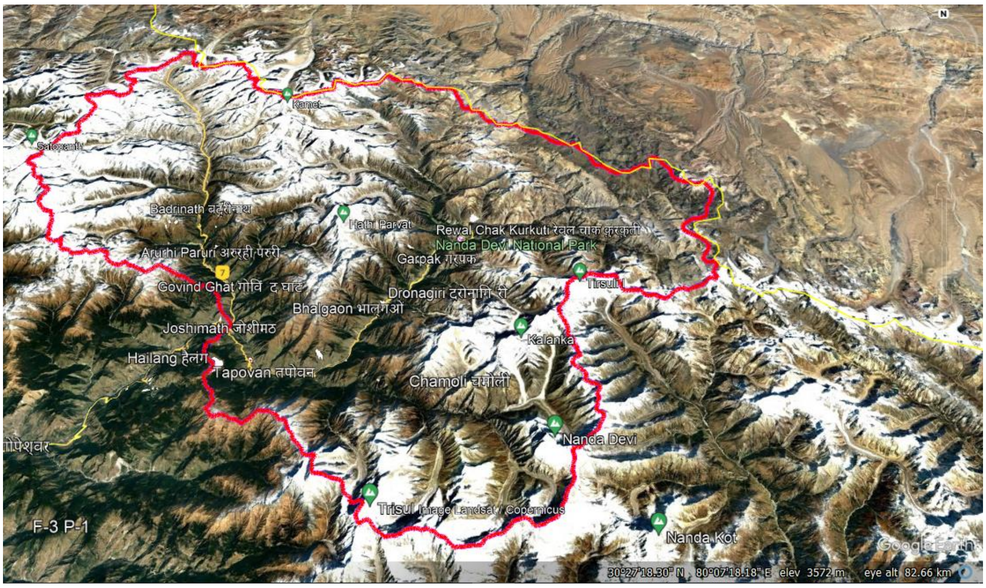


Figure 2: The study area location map

Objective of the study

This study presents the results of the GIS-based statistical models for generation of landslide susceptibility mapping using geographic information system (GIS) and remote-sensing data for the various part of Alakananda valley, Uttarakhand, India. The main objectives of the study are

1. Preparation of thematic maps for active and old landslide for the study area from Google Earth imagery.
2. Landslide susceptibility mapping using geographic information system (GIS) and remote-sensing data for the various part of Alakananda valley, Uttarakhand, India.

Methodology

Landslide susceptibility mapping is the spatial prediction of landslide occurrence by considering causes of previous events (Guzzetti et al., 1999). It largely depends upon knowledge of slope movement and controlling factors (Yalcin, 2008). slope, aspect, and curvature, topographic wetness index (TWI), normalized difference vegetation index (NDVI), Stream Power Index (SPI), lineament density and lithology.

The AHP method was used to find the relative weight and priority of individually factor and sub-factor causing landslides in the high altitude of Alakananda river basin. AHP is an approach to decision-making multi-objective multicriterion, which allows the user to arrive at a scale rather pulled off a set of alternative solutions (Saaty, 1980). It helps decision makers to discover the best suits of their objective and their understanding of the problem. This method is widely used in landslide susceptibility analysis.After developing the landslide susceptibility map of the Alakananda river valley, it was necessary to verify the accuracy of the landslide susceptibility model used in this study. A proper validation was conducted by comparing between the map obtained from the AHP model and the landslide inventory map.

Landslide Conditioning Factors

In this study, seven conditioning factors were selected based on the literature, effectiveness, availability of data, and the relevance with respect to landslide occurrence [23]. These conditioning factors are slope, aspect, and curvature, topographic wetness index (TWI), normalized difference vegetation index (NDVI), Stream Power Index (SPI), lineament density. All the selected conditioning factors were calculated using Alos and Landsat data and used to perform the landslide susceptibility mapping.

In the present study, various thematic maps were prepared by digitized from Google Earth imagery, topographical and geological maps of the area. All the data layers have been constructed and combined in ArcGIS 10.4 tool. ArcGIS tool was applied throughout the whole process in this study. Accordingly, the FR and SE models were used to generate elaborative landslide susceptibility maps. For the purpose of assessment and validation of landslide susceptibility maps, the AUC methods were used.

Landslide mapping in Geographical Information System (GIS) using remote sensing data

High-resolution satellite data (DEM of ALOS having 12.5 m resolution and Landsat 25 m resolution of 2020) was used in retrieving information related to topography, existing landslides, debris accumulation and other relevant features in relation to slope instability.

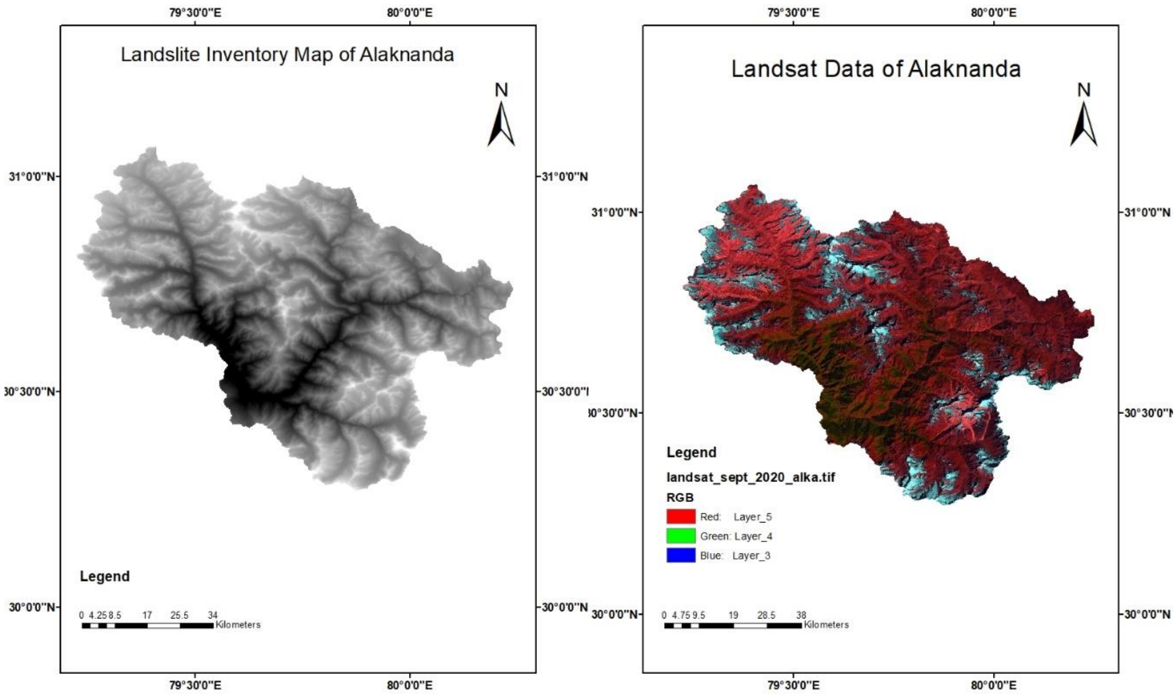
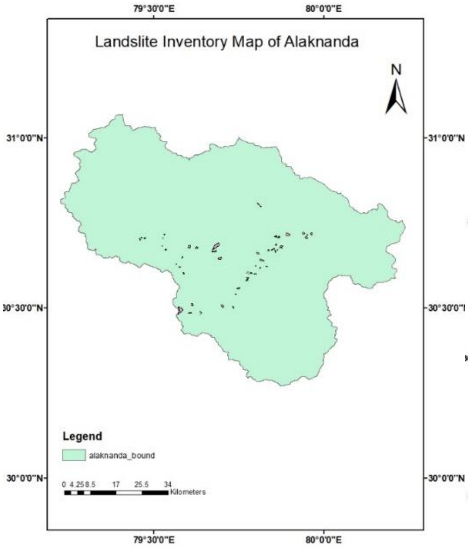
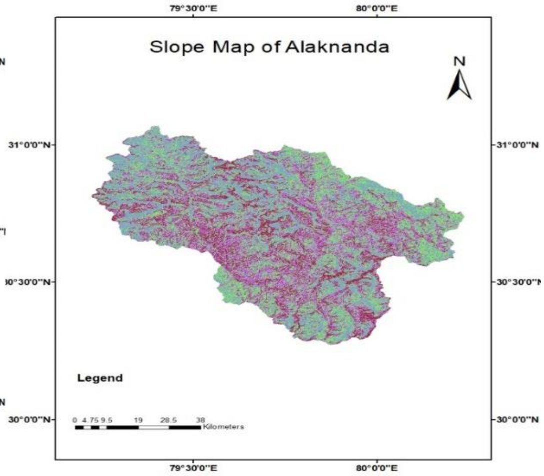
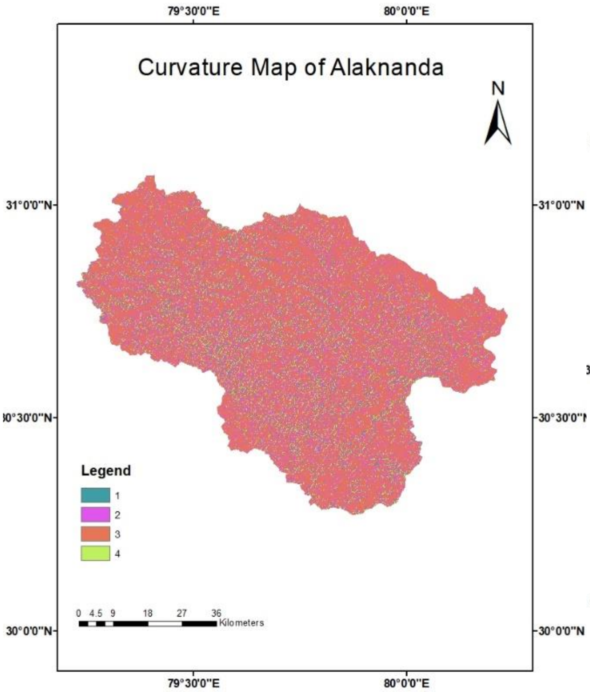


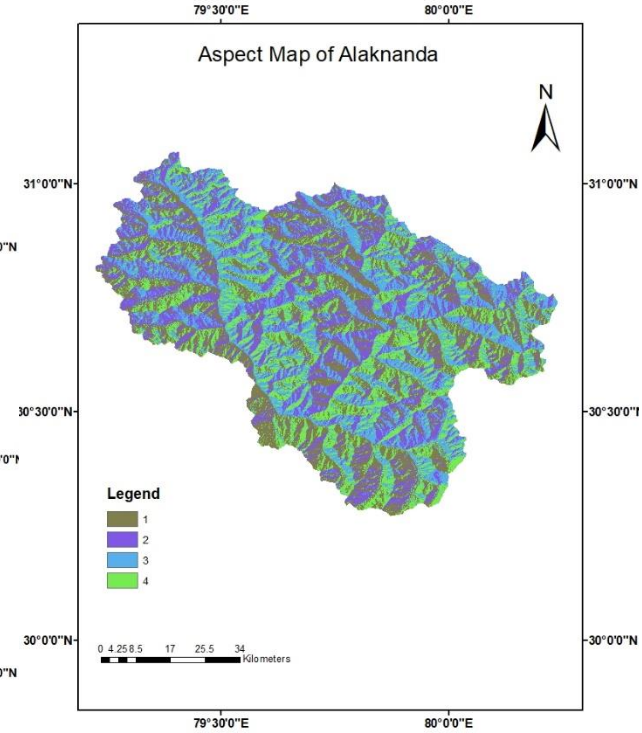
Figure 3: DEM of ALOS having 12.5 m resolution and Landsat 25 m resolution of 2020

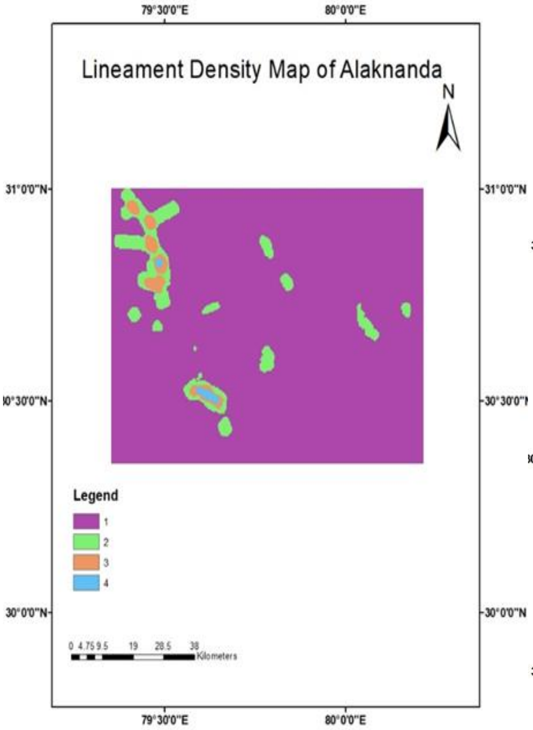
Workflow of the methodology.

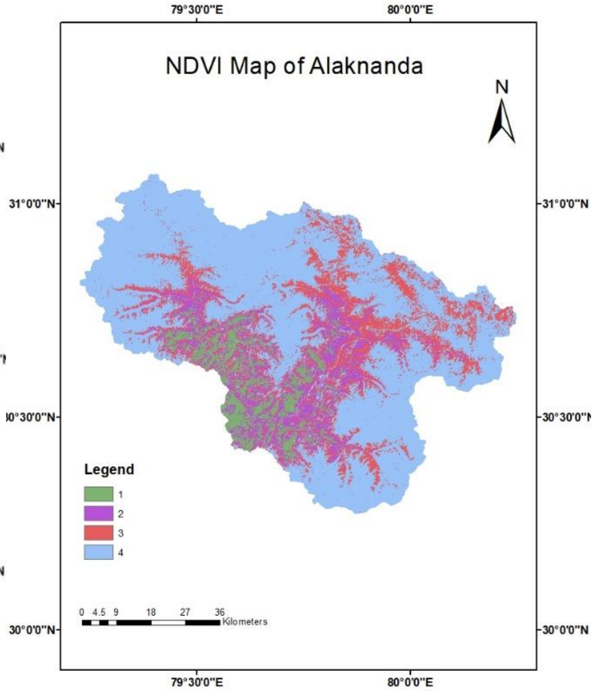

Landslite Inventory Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°30'0"N
30°0'0"N
Legend
alaknanda_bound
0 4.25 8.5 17 25.5 34
Kilometers

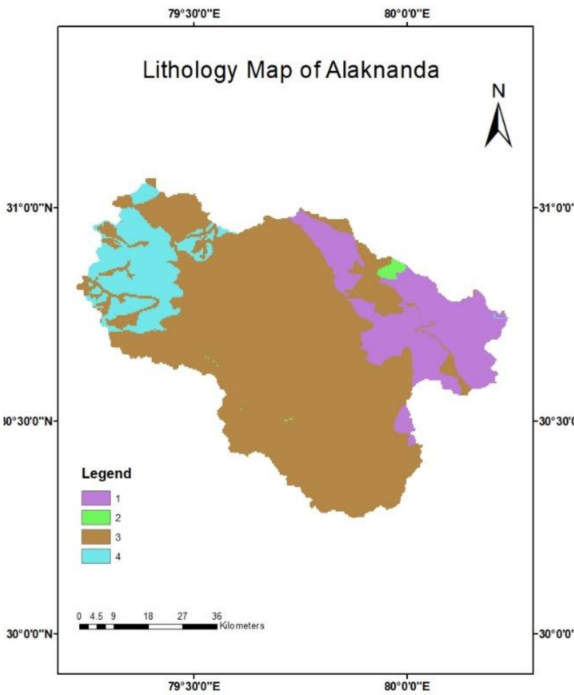

Slope Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°30'0"N
30°0'0"N
Legend
0 4.75 9.5 19 28.5 38
Kilometers

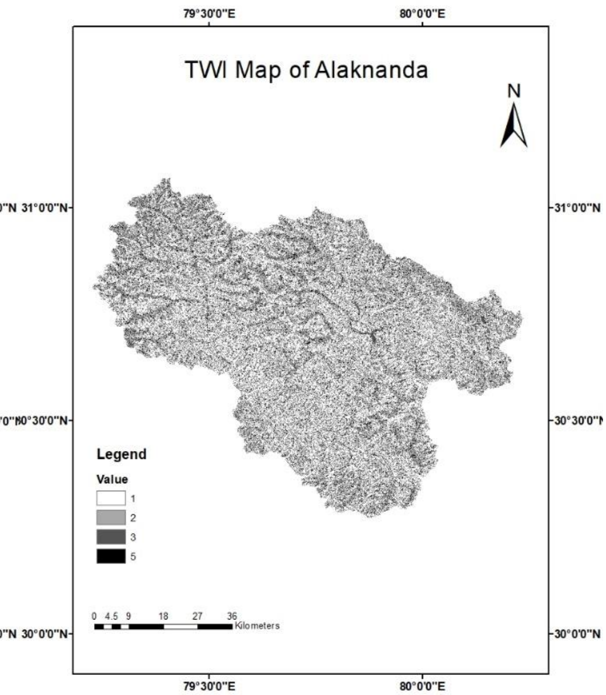

Curvature Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°30'0"N
30°0'0"N
Legend
1
2
3
4
0 4.5 9 18 27 36
Kilometers

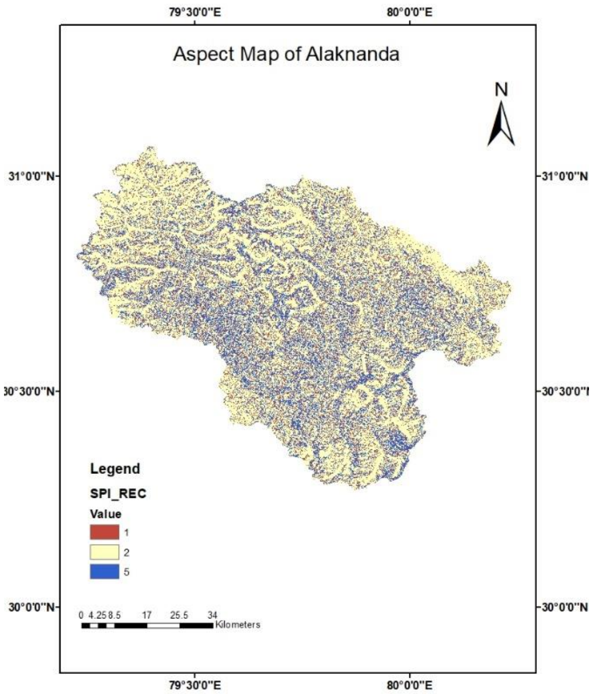

Aspect Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°30'0"N
30°0'0"N
Legend
1
2
3
4
0 4.25 8.5 17 25.5 34
Kilometers


Lineament Density Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°0'0"N
Legend
1
2
3
4
0 4.75 9.5 19 28.5 38
Kilometers


NDVI Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°30'0"N
30°0'0"N
Legend
1
2
3
4
0 4.5 9 18 27 36
Kilometers


Lithology Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°0'0"N
Legend
1
2
3
4
0 4.5 9 18 27 36
Kilometers


TWI Map of Alaknanda
N
79°30'0"E
80°0'0"E
31°0'0"N
30°0'0"N
Legend
Value
1
2
3
5
0 4.5 9 18 27 36
Kilometers



Results and Discussion

In this study, a GIS-based AHP as a multicriteria evaluation approach was used to identify the potential landslide occurrences in the Alakananda river valley.

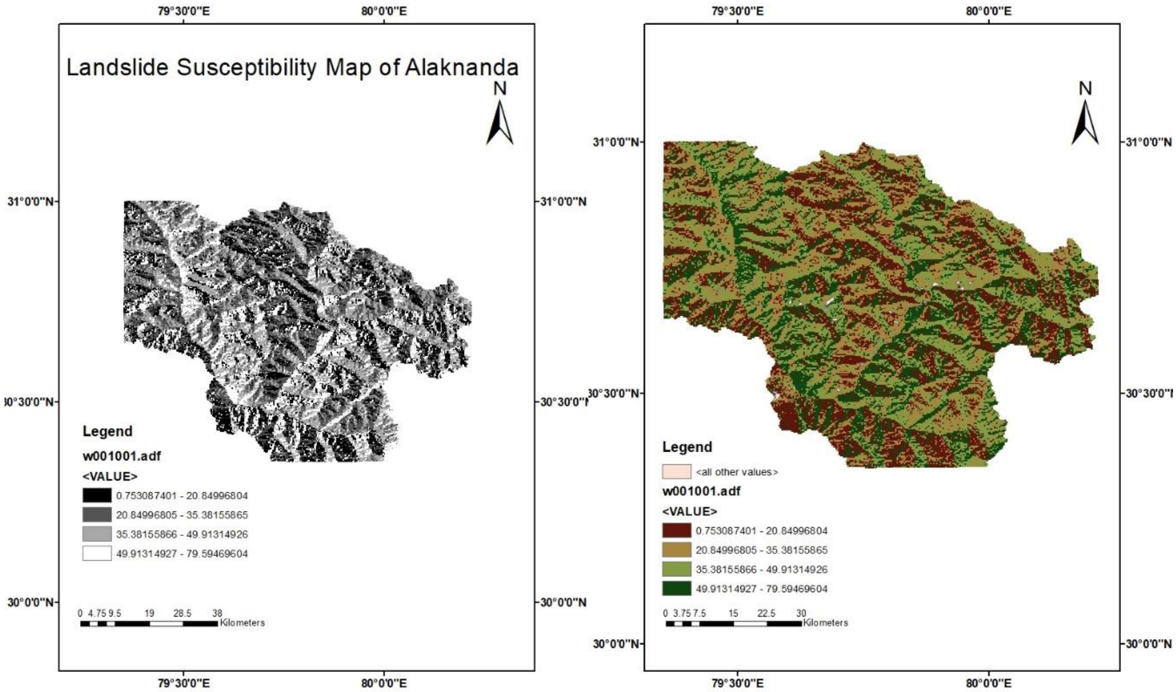
There are eight parameters used in this study.AND They are slope, aspect, and curvature, topographic wetness index (TWI), normalized difference vegetation index (NDVI), Stream Power Index (SPI), lineament density,Lithology were employed for susceptibility analysis. The AHP model is conventionally based on a rating system provided by expert opinion.Data collectected from various sources .Lithology map from Bhukosh(GSI), slope,aspect,curvature, and Normalized Topographic Wetness Index (TWI) map produced from Digital Elevation Model (DEM) data and Normalized Difference Vegetation Index (NDVI) map produced from Landsat image. All data must be converted to raster data based on the attribute data before analyzed using Spatial Analyst inArcGIS 10.5. The relationships between the detected landslide locations and the related factors were identified by using GIS-based statistical models including analytical hierarchy process (AHP). Landsat images and Google Earth dataset (Google earth pro) were used to construct the inventory map of Alakananda valley region area and the map which inventory map which has a total of 84 landslide locations was created based on resource like google earth pro-, Then, the landslide inventory map prepared and used for used for validation purpose.

Pair Wise Calculation

Parameter	Weight	Slope	Aspect	SPI	TWI	NDVI	Lineament	Curvature	Mean geometric
Slope	9	1.00	1.13	1.29	1.50	1.80	2.25	3.00	1.595860527
Aspect	8	0.89	1.00	1.14	1.33	1.60	2.00	2.67	1.41854269
SPI	7	0.78	0.88	1.00	1.17	1.40	1.75	2.33	1.241224854
TWI	6	0.67	0.75	0.86	1.00	1.20	1.50	2.00	1.063907018
NDVI	5	0.56	0.63	0.71	0.83	1.00	1.25	1.67	0.8865891815
Lineament	4	0.44	0.50	0.57	0.67	0.80	1.00	1.33	0.7092713452
Curvature	3	0.33	0.38	0.43	0.50	0.60	0.75	1.00	0.5319535089
	Total	4.67	5.25	6.00	7.00	8.40	10.50	14.00	7.447349125

Normalized weight

Parameter	Weight	Slope	Aspect	SPI	TWI	NDVI	Lineament	curvature	Mean geometric	Normalized weighted mean
Slope	9	0.214	0.214	0.214	0.214	0.214	0.214	0.214	0.2142857143	0.214
Aspect	7	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.1904761905	0.190
SPI	6	0.167	0.167	0.167	0.167	0.167	0.167	0.167	0.1666666667	0.167
TWI	5	0.143	0.143	0.143	0.143	0.143	0.143	0.143	0.1428571429	0.143
NDVI	6	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119047619	0.119
Lineament	6	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.09523809524	0.095
curvature	3	0.071	0.071	0.071	0.071	0.071	0.071	0.071	0.07142857143	0.071
		1.00	1.00	1.00	1.00	1.00	1.00	1.00		1.00



The final landslide proneness map is obtained and it is divided into 4 categories which is mentioned in the above table.

Sl.No	Range	Area	Locations
1	Very High	15sq km	6
2	High	21.8sq km	17
3	Moderate	41sq km	13
4	low	7sq km	4

The very high prone area is about 15 sq. km, the moderate prone area is 17sq.km, the moderate prone area is 13 sq.km and the 7 15 sq. km is the least landslide occurrence zone in the present study area.

Conclusion

Landslide susceptibility zone mapping using Geoinfomatics helps to delineate the disaster-prone areas. Landslide susceptibility was estimated by assuming that future landslides are possible to predict based on past landslides.The present study is an attempt towards remote sensing and GIS-based landslide hazard assessment along Alaknanda valley. Using the approach presented here, a few potential landslide hazard zones contain active landslides were identified in the upper reaches of the Alaknanda valley. The landslide intensity has been considered here as the measure of hazard It was six locations are found and it covers 15 sq km area including Kosa – Baras, Niti are the Very high risk landslide prone region. 16 high risk in category locations were noticed in Pipalkoti–Badrinath highway region and and also Garpat region it covers nearly 21 sq km. Moderately risk landslide prone area locations spotted in the region of Govind Ghat, Jumma and Jalam area covering approaximately 41 sq km. The landslide susceptibility map of the Alakananda valley provides valuable information about present and future landslides, which makes it viable. Such map may be helpful for planners and decision makers for land-use planning and slope management.

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