(AGUIJET) 2018, Vol. No. 7, Jul-Dec e-ISSN: 2455-0442, p-ISSN: 2455-6734

LANDSLIDE SUSCEPTIBILITY MAPPING USING INFO VALUE METHOD BASED ON GIS

[1]Sonia Sharma, [2]Mitali Gupta and [3]Robin Mahajan

[1,2,3]Assistant Professor, AP Goyal Shimla University

Email: sonia23790@gmail.com

Email: mitaligupta93@gmail.com

Email: ce.74508@gmail.com

ABSTRACT

Landslide susceptibility is the spatial prediction of landslide in an area identified on the basis of local terrain conditions. Landslide Susceptibility Mapping (LSM) depicts areas likely to have landslides in the future by correlating some of the principal factors that contribute to land sliding, considering the past distribution of slope failures. The study deals with information value method approach for Landslide susceptibility mapping for a part of Hamirpur district, in Himachal Pradesh using data layer's spatial analysis in Geographical Information System. Seven important causative factors for landslides are selected and corresponding thematic data layers are prepared in GIS. The input data is collected from the Geological maps, topographic maps, field data and published maps. Numerical weights for different categories of these factors are determined based on a info value approach and then integrated in GIS environment to arrive at landslide susceptibility map of the area. Finally, Landslide susceptibility maps are classified into four parts of landslide susceptible zones i.e., very low, low, moderate, high, very high. Study showed that fault distance from road, stream distance and slope have major role in contribution of landslide occurrence.

Keywords- Landslide susceptibility mapping (LSM), Info value, GIS

Introduction

Landslides are destructive phenomenon which causes fatalities and financial losses every year. Due to increase in urbanization, hill slopes are being disturbed by different construction activities particularly the road construction. Hence, it's necessary to know the landslide prone zones prior to construction activity so that adequate control measures can be adopted in time. For this, Landslide susceptibility mapping, which delineates the potential landslide zones is useful. The reason of occurrence of landslides is favorable terrain conditions, which is further triggered by rainfall, human activity, earthquakes and several other factors. Landslide is natural phenomenon which can't

(AGUIJET) 2018, Vol. No. 7, Jul-Dec **e-ISSN: 2455-0442, p-ISSN: 2455-6734**

be controlled but loss to life and property can be reduced if it is predicted in advance. Landslides occur due to a combination of mechanisms and susceptibility factors such as geology, steep slopes, rugged topography, variable climatic conditions, rainfall, earthquake and vegetation degradation. An area is declared susceptible to landslide when the terrain conditions at that site are comparable to those in an area where a landslide has occurred. Within the quantitative approach Info value technique for landslide susceptibility analysis are used.

STUDY AREA

In the present study, the study area lies between 76°15’ and 76°35’ longitude and 31°28’ and 31°37’ latitude in hilly terrain of Lower Shiwalik in Himachal Pradesh from Anu (Hamirpur) to Tihra road (Hamirpur). The study area is taken as 30km of NH-70.

METHODOLOGY

Information value method was developed in 1993 by Yin and Yan. It is a statistical method for spatial prediction of an event based on the parameter and event relationship. This method evaluates the actual landslide based on the spatial distribution of landslide controlling factors. This method is dependent on the experience and skills of the expert preparing the map. It requires a prior knowledge on factors controlling landslides. It has been very useful method for landslide susceptibility mapping by determining the influence of parameters governing landslides in an area. It is an indirect statistical approach that has the advantage of determining landslide susceptibility in an objective way.

The method allows the quantified prediction of susceptibility by means of a weight , even on terrain units that are not yet affected by landslide occurrence. Each instability parameter is crossed with the landslide distribution, and weighting values based on landslide densities are calculated for each factor class, as it happens with all bivariate statistical methods. The method implies prior definition of terrain units and the selection of a set of instability parameters. In this method weight is determined which allows the quantified prediction of susceptibility. Causative factor layers are individually crossed with the landslide distribution layer and the weighting values based on landslide densities are calculated for each parameter class. InfoVal is defined as the logarithm of the ratio between the density of landslide in a class over the density of landslide for the whole study area.

InfoVal is defined as the logarithm of the ratio between the density of landslide in a class over the density of landslide for the whole study area. It is a bivariate statistical analysis, which considers the probability of landslide occurrence within a certain area of each class of a thematic layer over which the weights of a particular class in a thematic layer are determined as:

(AGUIJET) 2018, Vol. No. 7, Jul-Dec e-ISSN: 2455-0442, p-ISSN: 2455-6734

$$Wi = \left(\frac{Densclas}{Densmap}\right) = \ln \frac{\frac{Npix(S)}{Npix(Ni)}}{\sum_{i=1}^{n} Npix(Si) / \sum_{i=1}^{n} Npix(Ni)}$$

Where, Wi is the weight given to the ith class of a particular thematic layer, Densclas is the landslide density within the thematic class, Densmap is the landslide density within the entire thematic layer, Npix(Si) is the number of landslide pixels in a certain thematic class, Npix(Ni) is the total number of pixels in a certain thematic class, and n is the number of classes in a thematic map. The natural logarithm is used to take care of the large variation in the weights.

Using the maximum and minimum Wi values of all layers, the results were stretched . Finally, the weighting factor ranging from 1 to 100 for each layer was determined by the following formula equation :

$$Wf = \frac{(TWi)-(MinTWi)}{(MaxTWi)-(MinTWi)} * 100$$

where, Wf is the weighting factor calculated for each layer, TWivalue is the total weighting index value of cells within landslide bodies for each layer, MinTWivalue is the minimum total weighting index value within selected layers and MaxTWivalue is the maximum total weighting index value within selected layers.

By executing this equation , the weighting factor (Wf) value of each layer has been depicted in (Table 1). For the analyses, the Wf value for each layer was multiplied by the Wi value of each attribute. Then all causal factors maps were summed up to yield the final landslide susceptibility zonation map using modified Infoval method.

Preparation of thematic maps

Various causes related to the instability of the slope are identified and their thematic maps were prepared . These maps are based on the Survey of India toposheets (www.nrsc.gov.in) as well as field data, and help from DEM was also taken from website.

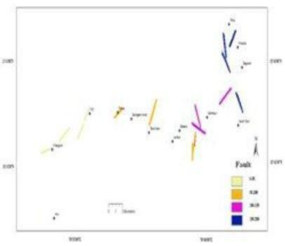
i. Soil:

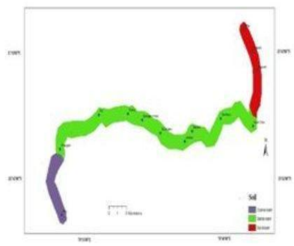
Soil basically involves the composition, texture, degree of weathering, as well as other details that influence the physio-chemical and engineering behaviors such as permeability, shear strength, etc.

(AGUIJET) 2018, Vol. No. 7, Jul-Dec **e-ISSN: 2455-0442, p-ISSN: 2455-6734**

of the rocks and soils. These characteristics in turn affect the slope stability. The soil map was prepared in GIS by following the published geological maps and field checks. There are major three soil types i.e rock, sand, loam. The dominant soil is sandy loam.

Fig1. Soil map of study area **Fig2. Fault map of study area**



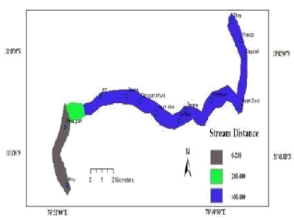


ii. Structure:

Joints, fault, thrust, shear zones are important factors and they affect the stability of the slope. It was observed that concentration of slide zones was observed in the vicinity of the major faults/thrusts; therefore, the rating for structure was presented on the basis of distance from the faults.

iii. Slope map:

On the basis of DEM and toposheet, a slope map of the area was prepared. Furthermore, the individual slope category was divided into smaller facets of varying slope angles have been imposed on the faces.



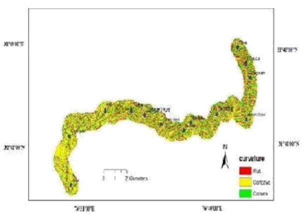


Fig3. Slope map of study area **Fig4. Landuse map of study area**

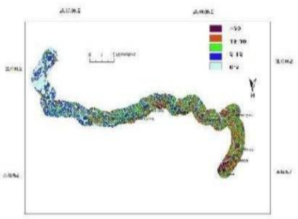
iv. Landuse:

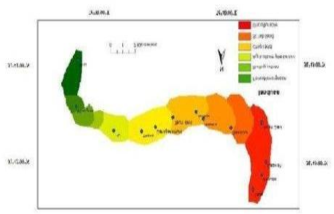
The study area may be divided into various landuse/land cover categories like agriculture land , forest, builtup, urban,crop land, unculturable land. On the basis of the field observations, the rating has been given for the different categories of the landuse and land cover.

v. Hydrological conditions:

The instability of the slopes is affected by surface as well as sub-surface water. The study shows distance from drainage patterns depicted the condition of surface water. For the susceptibility purposes, the surface indications of ground water and surface was observed as dry, damp, wet and flowing conditions. These observations were taken for individual slope faces.

Fig5. Stream Distance map of study area Fig6. Curvature map of study area





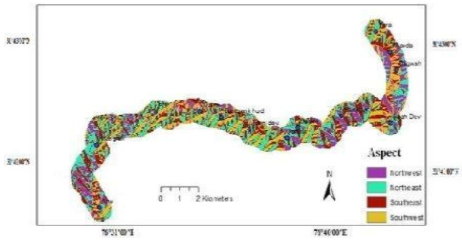
vi. Curvature:

Curvatures are used for presenting detailed of plan curvature and its effect on hill-slope stability in earth flow and earth slides dominated regions. Plan curvature is the curvature of the topographic contours or the curvature of a line formed by the intersection of an imaginary horizontal plane with the ground surface. Hillsides can be concave, convex and flat.

vii. Aspect:

Aspect (slope orientation) influence the exposure to sunlight, wind and precipitation hence indirectly affecting other factors that contribute to landslides such as soil moisture, vegetation cover. The aspect of the area is classified into northeast, southeast, southwest, northwest facing classes. The number of landslides is higher in the aspect classes of SE, NE and values of SW , NW facing slopes were found to be significant in causing landslides.

Fig7. Aspect map of study area



Data integration and analysis

To determine the effect of each factor towards landslide hazard, the existing landslide distribution data layer has been compared with various thematic data layers separately. The number of landslide pixels falling on each class of the thematic data layers has been recorded then weights have been calculated using equation of info value method.

The resultant weighted thematic maps have been overlaid and numerically added to generate a Landslide Susceptibility Index (LSI) map.

$$LSI = Sl + As + Ed + Li + + Stdis + Lu + Cr + Ft$$

where Sl , As , Ed , Li , Sd, Lu , Cr , Ft are the product of derived weights and weight factor for slope, aspect, euclidean distance, lithology, stream distance, landuse , curvature, fault respectively.

RESULTS AND DISCUSSION

The derived weights were assigned to the classes of each thematic, respectively, to produce weighted thematic maps, which have been overlaid and numerically added in GIS environment to produce a Landslide Susceptibility map. In the present study the relative area of susceptibility index values has been segmented into four zones representing four landslide susceptibility zones, viz., very low, low, moderate and high.

From the map, it is observed that about 5% of the total study area lies under high susceptibility, 52% is moderate susceptible to landslides, 36% lies under low susceptible zone and 7% lies under very low landslide susceptible zone. Hence this 5% area is highly sensitive and occurrence of landslides in this area is most probable. It is also found that most of the landslides take place on the curves. It is necessary to take care of such area that is under high and moderate susceptibility. The mitigation measures should be taken for such areas. The area that is moderately susceptible to landslides can get converted into high susceptibility if mining and construction activities take place there in future.

(AGUIJET) 2018, Vol. No. 7, Jul-Dec **e-ISSN: 2455-0442, p-ISSN: 2455-6734**

CONCLUSION

It is observed that about 5% of the total study area lies under high susceptibility, 52% is moderate susceptible to landslides, 36% lies under low susceptible zone and 7% lies under very low landslide susceptible zone.. It is necessary to take care of such area that is under moderate and high susceptibility. Some of the mitigation measures for highly sensitive area are also given after studying the susceptibility map. It is found that gabion walls are an effective mitigation measure and can reduce the hazards due to the landslides. Also, these are economical and easy to construct. Vegetation and grass can be grown on the denudated area, because root system of the grass is helpful in preventing the landslides.

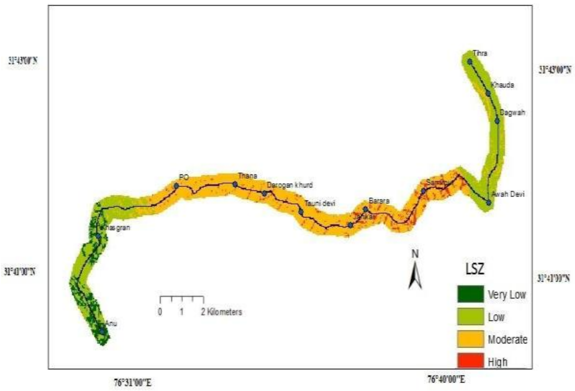


Fig8. Final landslide Susceptibility Map of study area

REFERENCES

[1] S. Sarkar, D.P. Kanungo, A.K. Patra and Pushpendra Kumar, " *GIS Based Spatial Data Analysis for Landslide Susceptibility Mapping*," Proceedings of J. Mt. Sci. 5: 52–62, 2008.

[2] S. Sarkar and R. Anbalagan, "Landslide Hazard Zonation Mapping and Comparative Analysis of Hazard Zonation Maps," Proceedings of J. Mt. Sci. 5: 232–240,2008.

[3] P. Aleotti, R. Chowdhury, "Landslide hazard assessment and risk evaluation: limits and prospectives," Proceedings Bull Eng Geol Env (1999) 58 : 21–44 Springer, 1999.

[4] Serwan M. J. Baban and Kamal J. Sant, "Mapping landslide susceptibility for the Caribbean island of Tobago using GIS, multi-criteria evaluation techniques with a varied weighted approach".

[5] Proceedings of Natural Hazards and Earth System Sciences, 5, 853–862, 2005.

[6] http/:www.nrsc.gov.in