

Analysing spatial interrelationship between landslides and thematic geofactors and quantitative validation of landslide susceptibility maps – A Case Study from Sikkim Himalayas

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Abstract

The Sikkim and Darjeeling Himalayas experience frequent landsliding events triggered by monsoon rainfall and intermittently by earthquakes. An inventory of 474 landslides has been prepared covering 1130 km of major road corridors in parts of Sikkim. This landslide database has been prepared on GIS format using ArcGIS 9.2 software. Out of 474 landslides, 236 are rockslides and 238 are debris slides. Out of 474 landslides, 177 are active, 42 are reactivated landslides, 241 landslides are dormant/ suspended whereas 14 landslides are stabilized/ relict. Out of the inventoried landslides, only 116 have been triggered due to the earthquake of 18th September, 2011 (6.9 Mw), rest are rainfall-triggered.

In this work, an attempt has been made to spatially correlate these landslide incidences by determining its density metrics with different thematic geodata for examining their spatial relationships with major causal factors such as topography, geology, land-use and cover, water saturation etc. Simultaneously, similar type of spatial interrelationship has also been established with the available macro-scale (1:50000) landslide susceptibility map of the terrain prepared in 2009 using BIS guidelines for validating and examining the susceptibility status of the terrain.

The above study revealed that the landslide density (i.e., number of landslide incidences per sq. km.) is maximum (0.66) within 35⁰-45⁰ slope category, followed by 25⁰-35⁰

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slope category (0.60). Within all the available lithologies, the inventoried landslides although present in all rock types but exhibits the highest landslide density (0.96) in high grade schistose rockmass and the least (0.38) in quartzites. Within the overburden material, the Younger loose material has the maximum landslide density of 1.33 and the older colluvium has the least landslide density (0.22). Within land-use and cover, the barren land has the maximum landslide density (0.85), whereas the thickly vegetated land and agricultural land have lower densities of 0.16 & 0.25 respectively. Hydro-geologically, the flowing category has the maximum landslide density (1.87), followed by dripping category (0.87).

Out of all the inventoried landslides, 257 spatially belongs to the High landslide susceptibility Zones with landslide density of 0.76. About 159 landslides belong to the Moderate landslide susceptibility Zone with density of 0.41 and the remaining 58 landslides are in Low landslide susceptibility Zones having landslide density of 0.24. Further the relative abundance (%) of earthquake triggered landslides in low, moderate and high susceptibility zones are 13%, 37.5% & 49.5% respectively; these abundances are almost similar to that of earlier landslide incidences (12%, 33% and 55%) which are largely rainfall induced. The above results validate the landslide susceptibility maps prepared along the road corridors of Sikkim during 2006-2009.

The above analysis and synthesis of the landslide incidences reveals further that compared to that of other districts, the occurrences of landslides along the roads of North Sikkim is higher. The same may be explained by relative higher abundance of high grade schist, younger loose material, fluvio-glacial material, dripping and flowing conditions of the slope forming material and relatively lower abundance of agricultural land along the roads of North Sikkim compared to other districts. This work successfully presents an analytical method to study the empirical relationships between landslides and their major causal factors and also proposes a simple quantitative technique of validation of the existing landslide susceptibility maps.

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