Remote sensing and GIS for Landslide Hazard Mapping in India - A Review

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Abstract:
Landslides are major natural hazards in hilly area, which cause significant loss of lives and damages to buildings, infrastructure such as roads bridges, agriculture including flora and fauna of the nature every year. In the past few years significant increase in landslide frequency took place, due to increase in the infrastructural development, deforestation and climate change. Remote sensing techniques represent a powerful tool for landslide investigation and its zonation. The aim of this paper is to give an overview on the applications of remote-sensing techniques for the landslide investigations, focusing on the achievements of the previous studies that have already been exhaustively reviewed in the existing literature. At the end of the paper, a new classification technique of remotely sensed imagery that may be pertinently adopted for investigating specific typologies of soil and rock slope failures is proposed.

Introduction
Remote sensing and Geographic information system (GIS) technique plays a very important role in forward planning. It provides the formwork for the planners and disaster managers to view spatial data by way of computer based maps. In the last decades, a significant increase in landslide frequency took place, in concomitance to climate change and the expansion of urbanized areas. Remote sensing techniques represent a powerful tool for landslide investigation. For the last few years lot of research has been done in this field has been done on identification of critical area of landslide.
Literature Review

Rai et al. (2014) discussed that slope plays a dominant role in creating gravity force which causes the landslides. He pointed out that mitigation of disaster due to landslides is successful only with the detailed knowledge about the expected frequency, character and magnitude of mass movement in the area. For his investigation he used the satellite imagery from LANDSAT ETM+, IRS P6, ASTER etc. along with survey of India (SOI) to derive the information on different parameters such as slope, relative relief, drainage density, aspect ratio and land use/land cover.

Landslide Zonation

Saha et al. did the Landslide zonation of Bhagirathi Valley in Garhwal Himalayas. For zonation they utilized the data collected from topographic sheets, geological maps, IRS-1B and 1D multispectral data, field observation and PAN sensor data. They observed that landslide distribution is governed by the combination of geo environmental conditions, barren land with less vegetation and Munsiai formation.

Kundu et al. generated map for the Zonation of landslides in Himalayan region. For study they considered area of 50Km² of Ganeshganga watershed in Chamoli district of Uttarakhand state to study the area using Bivariate statistical modified information value method. hey prepared the map using different factors responsible for landslides such as relative relief, structure, drainage density, distance to road, slope and other related factors were studied for generation of map with accuracy of 85%. Rana et al. identified zone in Mandakini Valley prone to landslides in geomorphically and climatically sensitive valley. They studied the role of anthropogenic activities in the areas which cause landslides in the valley. They also validated zonation map using post disaster landslides with accuracy of 77%.

Chandel et al. prepared the Zonation map of western Himalayan district of Kullu to Pirpanjal maintain range using remote sensing and GIS technique. They used the satellite imaginaries of ASTER, IRS P6, LANDSAT ETM and the map of survey of India topographical sheet prepared on the basis of different parameters such as drainage density, slope, aspect, drainage density and land cover. They classified the area into three categories No risk, very low to moderate, high and very high to high-severe landslide risk zones. There studied that more than 80% area is susceptible to severe Landslide risk and out of this 32% area comes under very high to severe risk. Lallianthanga et al. identified the Landslide hazard zones based on remote sensing and GIS technique with the help of satellite image technique. They observed that Cartosat-I stereo data and IRS (P6) LISS III data can be effectively used for the landslide hazard zonation mapping at district level which is important as Landslides are mostly confined to the inhabited parts of district.

Rawat et al. carried the Landslide Hazard zonation of south district, Sikkim state using remote sensing and GIS technique using various thematic layers such as slope, thrust buffer, geology and land use, photo-lineament buffer and relative relief map. They prepared the LHZ map showing the five zones, namely very low hazard, low hazard, moderate hazard, high hazard and very high hazard by using the slicing operation. Chandak et al. prepared the Landslide Zonation (LHZ) of Pakhi village prone to landslide hazard using GIS to protect the
inhabitants of the region. The LHZ map can be used to relocate people from hazardous zones to safer areas. The LHZ map has been classified into six zones for better strategic future planning namely as Very High Susceptibility, High Susceptibility, Moderate Susceptibility, Low Susceptibility, Very Low Susceptibility, Relatively Stable zones.

**Landslide susceptibility mapping**

Ghoshal et al. prepared the Landslide Susceptibility Map (LSM) based on six factors which caused landslides. The LSM Prepared show that 18.08% of the areas studied come under high and very high susceptibility classes and constituted 42.94% and 38.98 of the area studied. The authors pointed out that erosion of drainage, anthropogenic interference and heavy rainfall are the factors that cause landslides in the hilly areas. Das et al. classified the settlement area of Guwahati city based on the slope angle to identify the potential landslide risk zone. They used different types of data geological, Survey of India, topographical maps, IRS-1B and -1D. The Data integration was carried using ARCGIS software for risk assessment. They interpreted that the distribution of landslides is largely governed by a combination of geo-environmental conditions like presence of massive crystalline rocks is highly susceptible to seepage pressure, barren or less-vegetated areas and Toe cutting of the natural slopes for construction of dwelling houses.

Kishore et al. studied Patalganga drainage basin for landslides using GIS. They observed that valley as well as the road suffered most of the landslides and other mass movements due to unpredicted rainfall and the development activities in the region. The authors discussed the stepwise approach for the preparation of Landslide Hazard Potential (LHP) analysis for the preparation of Map using GIS platform which will be of great help for guiding the future development in the valley.

Rautela and Lakhera studied the Landslide risk analysis between Giri and Tons rivers in Himachal Himalaya (India). The area around Sataun in the Sirmur district of Himachal Pradesh, India (falling between the rivers Giri and Tons; both tributaries of the Yamuna River) was studied for landslide vulnerability on behalf of the inhabitants. The study was made using extensive remote sensing data (satellite and airborne). It is well supported by field evidence, demographic and infrastructural details and aided by Geographic Information System (GIS) based techniques. Field observations testify that slope, aspect, geology, tectonic plates, drainage, and land use all influence landslides in the region. These parameters were taken into consideration using the statistical approach of landslide hazard zonation. As most of the infrastructure in the region is concentrated around population centers, population data alone was used for vulnerability studies.

Kamp et al. GIS-based landslide susceptibility mapping for the 2005 Kashmir earthquake region. Geomorphology October 8, 2005 Kashmir earthquake triggered several thousand landslides throughout the Himalaya of northern Pakistan and India. These were concentrated in six different geomorphic geologic anthropogenic settings. A spatial database, which included 2252 landslides, was developed and analyzed using ASTER satellite imagery and geographical information system (GIS) technology. A multi-criterion evaluation was applied to determine the significance of event-controlling parameters in triggering the landslides. The parameters included lithology, faults, slope gradient, slope aspect, elevation, land cover, rivers and roads. The
results showed four classes of landslide susceptibility. Furthermore, they indicated that lithology had the strongest influence on landsliding, particularly when the rock is highly fractured, such as in shale, slate, clastic sediments, and limestone and dolomite. Moreover, the proximity of the landslides to faults, rivers, and roads was also an important factor in helping to initiate failures. In addition, landslides occurred particularly in moderate elevations on south facing slopes. Shrub land, grassland, and also agricultural land were highly susceptible to failures, while forested slopes had few landslides. One-third of the study area was highly or very highly susceptible to future landsliding and requires immediate mitigation action. The rest of the region had a low or moderate susceptibility to landsliding and remains relatively stable.

This study supports the view that earthquake-triggered landslides are concentrated in specific zones associated with event-controlling parameters; and in the western Himalaya deforestation and road construction contributed significantly to landslides during and shortly after earthquakes.

Conclusion

The landslide Zonation (LHZ) and Landslide susceptibility mapping are most important and critical tasks in the Landslide management process. Landslides bring misery to human and animals in addition to other losses of property, infrastructure and other related developmental activities in the area. The various observations of the authors are given below.

- The Remote Sensing and GIS techniques are very important for the preparation of the Zonation Maps of Landslide prone areas using information on different parameters such as slope, relative relief, drainage density, aspect ratio and land use/land cover.
- The LHZ is very important for the area prone to Landslide Hazards so that the danger and losses due them can be predicted in advance and losses are minimum. The Zonation Map provides the information for the minimum distance for the rescue operation in the area.
- The LHZ provide very important information for the alternative path during landslides.
- Landslide susceptibility mapping reveals that higher degree of landslide hazard is associated with geo-physical elements especially slope, relative relief and lithology of the area. The presence of faults, particularly in the vicinity of human occupancy enhances vulnerability. Vulnerability is compounded by mindless and rampant expansion of settlement onto vulnerable land and ambitious road construction that aids this settlement. In addition, anthropogenic activities play a significant role in triggering such events.
- Landslides distribution is governed by the combination of geo-environmental conditions barren land with less vegetation and Munsiari formation.
- The study reveals that critical re-evaluation of the current development is necessary for proper planned development to reduce the losses due to landslides.

Landslide Hazard Zonation (LHZ) mapping using integrated Remote Sensing and GIS technique was carried out so as to classify the land surface into zones of varying degree of hazard. Thus, the review on landslide hazard
zonation mapping produced through present study will be useful to the planners and engineers. LHZ mapping is essential for strategic planning to minimize the damages caused by landslides. The LHZ map has been classified into six zones for better strategic future planning namely as Very High Susceptibility, High Susceptibility, Moderate Susceptibility, Low Susceptibility, Very Low Susceptibility, Relatively Stable zones. The factors responsible for causing Landslides must be kept in mind during the development activities of the area. The natural stability of slopes get disturbed due to the road construction, fragile geological conditions, groundwater and uncontrolled surface run-off which favor landsliding during rainy season.

References


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