An inventory study on Landslide Hazard Zonation of Kullu Valley of Central Himalayan zone, Himachal Pradesh, India

R.S. Banshtu and Laxmi D. Versain

Abstract—The Himalayan terrain is highly active mountain range among the wide mountain chain/belt of the world. Fragile nature of rocks, changing slopes, deforestations, highly charged rivers are prevailing factors on mountains. Mountain hazards have largely been encountered since the landslides are widely degrading the environment and its surrounding at a great pace. Several factors responsible for such activities results in degradation of environment and serious ecological imbalances. The distribution of reported landslides widens with the passage of time in district Kullu. The frequency of landslides has grown very fast in the town and at places reached the crises due to wide geographic changes and losses to life. Therefore scientific planning and approach is required to identify landslide prone area and integrate all the possible measures to minimize the losses by suitable mitigation methods.

Index Terms—Zonation, Hazard, Inventory, ARC GIS.

I. INTRODUCTION

Kullu district is situated on the banks of almighty river Beas and falls in Middle Himalayan zone and experiences landslides of various form and dimensions, types and descriptions. In the district, Landslide activities are largely associated with tectonically active Himalayan mountain ranges (Sarkar et. al. 1995; Rautela & Thakur, 1999, Anabalagan et. al. 2008; Chauhan et. al. 2010). The Himalayan hills are prone to landslides mainly due to excessive rainfall along with human activities like road cutting and land use for construction and mining purposes. The entire area witnesses landslide activities mainly due to mining and toe cutting of hill slopes which eventually results in slope instability. Suitable mitigation measures are taken to restrict the hill cutting, illegal mining and deforestation.

II. PROPOSAL

The proposal is a work on the landslide zonation in Kullu district of Himachal Pradesh, India. The temperature of the Study Area remains between 4-30°C. The Valley lies in Kullu district of Himachal Pradesh situated in the central Himalayan zone (Fig. 1a). The area lies in a latitude and longitude of 32° 35’ N and 77° 06’ E. The temperature of the region remains between 4-30°C within the Study Area throughout the year. The area falls under mountainous region to flat valleys in lower part of the district. The elevation of the district varies from 1100 meters to 4000 meters in an intricate system of mountain ranges which are the result of successive compression movements of the earth’s crust (Burrard and Hayden, 1933).

Fig. 1(a) Political Map of Himachal Pradesh

The district (Fig. 1b) has very high absolute relief ranging from 750-6200 meters. The geomorphological character of Kullu is influenced by both glacial and fluvial processes (Sah & Mazari, 2007); the area is broadly divided into glaciers & permanent snow fields, rocky/barren slopes, valley slopes & ridges, and main valley floor (Fig. 8). Kullu district, one of the most favoured tourist destinations, is a landslide prone area and there has been a number of landslides in the region i.e Lugarbhati landslide, Hurla landslide, Rahjinallah landslide, Gulaba camp landslide (Fig. 3).

Fig. 1(b) Relief Map

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The landslide study of the area is carried out by using Survey of India topographic sheets; 52H/3, 52H/7, 52D/16, 52H/4, 52H/8, 52H/16, 53A/1, 53E/A, 53E/5, 53E/9, 53E/13. The maps pertaining to Kullu district area are collected and digitized using Arc GIS 10.1 and Erdas 9.3 for landslide mark, generating Digital Terrain Model, Slope (degree) and aspect map, relative relief map, drainage density and geology map respectively. Slope, aspect, relative relief and geology maps are derived from LISS III of 1D satellite whereas landslide sites identification is derived by using image enhancement techniques through ERDAS IMAGINE 9.2 (Table 1). Field data is collected from respective sites of landslide locations and geology of the area is observed, based upon this data the inventory of actual landslides sites in district are prepared.

### Table I

<table>
<thead>
<tr>
<th>S. No</th>
<th>DATA TYPE</th>
<th>SCALE</th>
<th>USE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Topographical Sheet</td>
<td>1:50,000</td>
<td>Contour plan and DEM of area</td>
</tr>
<tr>
<td>2.</td>
<td>Satellite data LISS-III - 1D</td>
<td>NRSC, Hyderabad</td>
<td>Spatial Resolution 23.5 m. Area mark &amp; landslide sites identification</td>
</tr>
<tr>
<td>3.</td>
<td>Geological Map</td>
<td>Scale 1:50,000</td>
<td>Geology, Lithology, Discontinuities</td>
</tr>
<tr>
<td>4.</td>
<td>Field Data</td>
<td>Locations from GPS</td>
<td>To mark Landslide locations</td>
</tr>
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</table>

**Analysis & Discussion**

Slope and aspect are important triggering factors that determine the hazardousness of an area. The slope degree refers to the rate of change in elevation over distance with lower slope value representing flatter terrain and higher value is representing steeper terrain (Fig. 5). Aspect defines the down slope direction of the maximum rate of change or the direction of steepest slope in x-y plane (Fig. 4).

In study area gentle slopes (below 20°) form nearly 1/3 (33.40%) of total area of the district. The moderately steep and steep slopes account for 36.55% and 25.20% area (Fig.7) respectively; about 7 percent of the total area possesses very steep (above 40°) slopes. The aspect distribution in the district has an even distribution as all eight directions have 10-15 per cent of total area (Fig. 4). The aspect has significance in understanding the slope stability. Usually southeast (SE) to south (S) and southwest (SW) slopes are comparatively more prone to slope failure and sliding activities.
IV. CONCLUSION

The required database for the research projects includes inventory of landslides sites, field exposures and an insight of geological phenomenon that drive such hazards. The landslides mostly observed are of rock fall and debris flow. The occurrences of the slides are mainly due to excessive rains, road cutting and river cutting. Road cutting and river cutting are found to be main causes for almost all debris flow in both banks of river Beas. The large part is on the verge of sliding which was confirmed by tension cracks seen near the crown of the slide. It posed great threat to the population inhabiting downhill. The occurrence of rock falls are slightly prominent on upper basin of Beas river. Different maps are overlaid and processed using Analytic Hierarchy Process to generate the landslide hazard susceptibility map of Kullu valley. The data thus generated is co-related the results of AHP (Analytic susceptibility map) with actual inventory obtained in the field. The majority of landslides are occurred near the occupancy of the human interferences and vulnerability of hill slope cuttings and uncontrollable settlements. The analytic approach will provide the results of the research to for further precautionary and development measures.

REFERENCES


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