Probabilistic Hazard Analysis of Rainfall –Induced Landslide in the Higher Himalaya, Western Nepal

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1 Introduction

Landslide hazard mapping is a fundamental tool for disaster management activities in fragile mountainous terrains. The main purpose of this study is to evaluate the predictive power of weights-of-evidence modeling in landslide hazard assessment in the Lesser Himalaya of Nepal. The modeling was performed in geographical information system (GIS) to derive a landslide hazard map of the North-East marginal hills of the Achham district.

The area under study consists of various lakes, mountains and scenic places, so currently different agencies are involved in tourism infrastructure development. The main objective of this study is to prepare a hazard map of the area, which is expected to help in optimization of infrastructure lineament and slope stability mitigation measures.

Thematic maps representing various landslide inducing factors (e.g., slope, aspect, curvature, relief, flow accumulation, distance to drainage, soil depth, soil type, landuse, geology, distance to road, sediment transport index, wetness index and mean annual rainfall) were generated using field data and GIS techniques.

2 Statistical analysis

Weights-of-evidence modeling can be used for the landslide hazard and susceptibility mapping. It uses the Bayesian probability model, and was originally developed for mineral potential assessment (Bonham-Carter, 2002). This method has also been applied to landslide susceptibility mapping (Lee et al., 2002; van Westen et al., 2003, Lee and Choi, 2004, Lee and Sambath, 2006; Sharma and Kumar, 2007; Neuhäuser and Terhorst, 2007). Dahal et al. (2008) have also used this method for landslide hazard mapping in Nepal. Landslide events of the old landslides were used to assess the probability of landslides in each cell unit with respect to the causative factors.

The method calculates the weight for each landslide causative factor based on the presence or absence of the landslides within the area. The related mathematical relationships are described below.

The positive weights of evidence \( W^+ \) (Bonham-Carter, 2002) can be expressed as follows:

\[
W^+ = \log \frac{P\{F|L\}}{P\{F|\bar{L}\}} \quad \text{Eq. 1}
\]

Similarly, the negative weights of evidence, \( W^- \), is expressed as follows:

\[
W^- = \log \frac{P\{F|\bar{L}\}}{P\{F|L\}} \quad \text{Eq. 2}
\]

The final weights of evidence is:

\[
W_i = W_i^+ - W_i^- \quad \text{Eq. 3}
\]

The weights were assigned to the classes of each thematic layer, and the resultant weighted thematic maps were overlaid and numerically added to produce a Landslide Hazard Index (LHI) map based on the following relationship:

\[
LHI = \sum (\text{Slope} \times W_{\text{Slope}} + \text{Aspect} \times W_{\text{Aspect}} + \text{Disdrn} \times W_{\text{Disdrn}} + \text{Curv} \times W_{\text{Curv}} + \text{Disrd} \times W_{\text{Disrd}} + \text{STI} \times W_{\text{STI}} + \text{Wet} \times W_{\text{Wet}} + \text{Rain} \times W_{\text{Rain}})
\]

\[
\text{Eq. 4}
\]

To assess the accuracy of the resulting landslide hazard map (Fig. 1), it was correlated with a map of landslides triggered by the 2009 extreme rainfall events. The accuracy of the map was evaluated by various techniques, including the area under the curve, success rate and prediction rate.

3 Concluding remarks

The resulting landslide hazard value calculated from the old landslide data showed a prediction accuracy of greater than 78.24%. The analysis suggests that geomorphological
and human-related factors play significant roles in determining the probability value, while geological factors play only minor roles. Finally, after the rectification of the landslide hazard values of the new landslides using those of the old landslides, a landslide hazard map is prepared.


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References


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References


