Chapter 7

Space-Time Integrated Landslide Hazard Zonation near Tehri Dam in Uttarakhand, India:

Integrated Landslide Hazard Zonation

Pooja Rana
Sphere India, India

Jeganathan Chockalingam
Birla Institute of Technology, India

Arvind Chandra Pandey
Central University of Jharkhand, India

ABSTRACT

The study aims to predict landslide hazard zones near Tehri Dam in Uttarakhand State located in the Western Himalayas in India. Four different models were analysed: Weight Factor Model (M1), Multiple Factor Model (M2), Statistical Bivariate model (M3) and Analytical Hierarchical Processes (AHP) model (M4). Five different combination of reference landslides were used for deriving weights of the classes in the factor maps: all the landslides from 1990, 2002 & 2010 (C1); landslides from

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2010 (C2); landslides from 1990 & 2002 (C3); landslides located within 500m from roads (C4); landslides located beyond 500m from roads (C5). The accuracy resulted from each model in each combination was [Mn:C1, C2…Cn]: M1: 60,44,46,38,66%; M2:70,76,79,73,71%; M3:45,37,23,36,85%; M4:64,51,51,64,36%. Multiple Factor Model (M2) resulted in a consistently high accuracy in all the combinations. Finally, the 20 different model outputs were integrated to derive unified hazard zonation maps based on: (a) mean (85% accuracy), (b) penalisation (57% accuracy) and (c) k-means cluster (80% accuracy) approaches.

INTRODUCTION

Landslide is a major and common natural hazard in a hilly terrain. In India, natural disasters such as earthquakes, floods, and especially landslides, are frequent and invariably impact rural (and national) economy. India has about 25% of its geographical area under mountainous terrain (Rautela & Pande, 2006). Himalayas and Shivalik ranges in north are new and unstable in comparison to the southern, central and western mountains namely the Western Ghats, Satpura, Vindhyan ranges and Aravalis which are geologically very old and stable formations. The Himalayan terrain witnessed large number of major and minor landslide events causing loss of human lives, property and disruption of environment (Petley, 2013). Recently there has been a very rapid increase in the developmental activities like large scale construction of roads, mining activity, overgrazing, deforestation and opening up of steep land for agriculture in whole Himalaya which cause severe erosion resulting in extensive slope failures. The damage caused by landslides in the Himalayas estimated to cost more than one billion US dollars, besides causing 200 deaths every year, which amounts to 30% of such losses occurring world-wide (Kanungo et al. 2009). Uttarakhand is a Himalayan state that is located between Nepal and Himachal Pradesh (India). The seismic risk in the state is evaluated to be high. In the past, the state has witnessed a large number of landslide events. Four of the thirteen districts (Pithoragarh, Chamoli, Bageshwar & Rudraprayag) of the state fall completely in Zone V of the seismic risk map of India while other five (Uttarkashi, Tehri Garhwal, Pauri, Almora & Champawat) fall partially in Zone V and partially in Zone IV (Rautela & Pande, 2006). In the past decade there were few major landslide events in Uttarakhand which caused huge loss in terms of property, human life and amenities.

Apart from development activities in the Himalayan terrain, these rocks are adversely affected by tectonic movements (in the form of intense shear, faulting, fracturing), surfacial and near surfacial processes (causing joints or cracks) and precipitation. These factors make the slopes more prone to landslides. Over the