Chapter 6
Debris Flow Modelling and Risk Assessment of Selected Landslides from Uttarakhand– Case Studies using Earth Observation Data

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ABSTRACT

Presently demand for process based modelling of mass movements encompassing snow avalanche, debris flows, landslides, mud flows and rock falls has increased manifold due to their devastating effect and mitigation challenges of disasters caused by such phenomena. Debris flows are multi-phase gravity-driven flows consisting of randomly dispersed interacting phases and therefore, are, extremely challenging to predict the dynamics, run-out distance and area of inundation related to such events which will facilitate mitigation as well as evaluation of simulated scenarios. The numerical simulation model predicts the motion of a geophysical mass movement from head to base in three dimensions. These process-based 3-D models can be utilized for better understanding of vulnerability of a complex mountainous terrain and design appropriate civil engineering structures to withstand the impact of potential flows like Ukhimath, Uttarkashi and Kedarnath.

DOI: 10.4018/978-1-5225-1814-3.ch006

INTRODUCTION

Himalayas, now, have almost become synonymous with landslides. The lower Himalayas have been susceptible to landslides since ages because of tectonically fragile and sensitive mountainous terrain (Ghosh & Suri, 2005). However, the susceptibility to landslides has increased many fold in recent past due to encroachment, infrastructure development, exploitation of natural resources, and so as the vulnerability because of unprecedented human settlements in Himalayan region. The man has put the placid and serene environment of Himalayas in quite strained conditions, thereby disturbing already stressed fragile environment and ecological balance. Consequently, the nature has retaliated through some of the catastrophic disasters in the form of landslides, floods, lake breaches etc. Kedarnath disaster of June 2013 is the most recent one of the many to name. Statistically, approximately 15% of Indian territory is prone to various degrees of landslide hazard where 300 human lives are swallowed and about Rs. 300 Crores property is lost every year.

Landslides in its firm sense are the movement of a mass of rock, debris or earth down slope, due to gravitational pull, and in general are triggered by a variety of external factors such as intense rainfall, earthquake shaking, water level change, storm waves and rapid stream erosion etc. (Dai et al., 2002). These triggering factors have an influence in increasing the shear stress and decreasing shear strength of slope forming materials beyond a threshold limit and which eventually cause failure and hence landslide. Though, landslides encompass a wide range of movements such as Debris flow, Creep, Slump, rock fall etc., however emphasis, here, has been restricted to debris flow only. Debris flows are often described as multi-phase gravity-driven flows consisting of randomly dispersed unsorted material ranging from clay to boulders. These multiple phases interact in a very complex way to lead to extremely hazardous events. According to (Varnes, 1978), which is a part of landslide classification, is commonly used and states that flow are rapid movements of materials as a viscous mass where inter-granular movements predominate over shear surface movement. These phenomena could be debris flow, mudflows or rock avalanches, depending upon the nature of the materials involved in the movement. Debris flow can further be classified into two types: hill-slope (open-slope) debris flow and channelized debris flow. Between these two hill-slope debris flows creates their own path down the valley slope as tracks or sheets, depositing their materials on lower slope gradient (Cruden & Varnes, 1996).

Pertinently, in the recent past, devastating landslides have occurred in the state of Uttarakhand such as Ukhimath in 2012 and Varunabat Parbat, Uttarkashi in 2003, Lambagarh in 2004, La landslide in 2009 and numerous landslides in 2013 including Kedarnath. In order to model their diversified events and assess geotechnical characteristics, RAMMS model was applied with the help of inputs derived

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Dilum Rukshan Perera, K. S. Mannathunga, R. A. D. D. Dharmasiri, Ravinda Gayan Meegamaand Kithsiri Jayananda (2020). *Sensor Technology: Concepts, Methodologies, Tools, and Applications (pp. 959-988).*
www.irma-international.org/chapter/implementation-of-a-smart-sensor-node-for-wireless-sensor-network-applications-using-fpgas/249601