Debris flow source-based susceptibility and propagation modeling: A case study from Garhi Habibullah to Balakot, Northwestern Himalayas, Pakistan

Muhammad Ali[1*], Javed Iqbal Tanoli[1], Hamza Mehsud[2], Tanveer Ul Haq[1], Ihsan Ullah[1], and Adeel Jehangir[3]

[1]*Deptt. of Earth Sciences, COMSATS University Islamabad, Abbottabad Campus,*

[2]*Badong National Observation and Research Station of Geohazards, China University of Geosciences, Wuhan 430074, China;*

[3]*Deptt. of Geology and Environmental Sciences, Univ. of Pittsburgh, 4107 O'Hara Street, Pittsburgh, USA*

[*]*Email: alieeashraf@gmail.com*

Balakot is situated at the heart of the Hazara Kashmir Syntaxes. Characterized by high and steep slopes, active seismic zones, adverse climatic conditions, monsoon rainfall, and an active Bagh-Balkot fault, the region is highly susceptible to natural hazards. These include debris flows and landslides, which pose significant threats to both human life and infrastructure. Therefore, this study aims to achieve debris flow field-based inventory from Garhi Habibullah Khan to Balakot. A total of 12 debris flows were identified during the field. Later, the point-based inventory and delineation of sub-catchments were obtained using ArcMap. A total of 126 debris sources were marked through Google Earth Pro, contributing to debris flow channels. Subsequently, debris flow source datasets were randomly divided into two datasets. The first dataset comprised 70% (89) training source points and the second dataset comprised 30% (37) validation source points. Debris flow source-based susceptibility maps were prepared using a bivariate Statistical Index Model. The spatial database of nine causative factors was compiled using a 12x12 m Digital Elevation Model in ArcMap, including aspect, curvature, slope, elevation, lithology, rainfall, Topographic Wetness Index (TWI), fault buffer, and distance to stream. The propagation of debris flows was modeled using Flow-R software, and two propagation maps were generated using collapse material and susceptibility as source input. Flow-R results show low to moderate propagation and validate already propagated debris flows in the study area. The Receiver Operator Curve (ROC) validated the model's performance

through success and prediction curves. Results show that the area under the curve (AUC) for the bivariate Statistical Index Model was 83.4% and 84.1% for success and prediction curves, respectively. The outcome of this study will be beneficial in proposing solutions for the potential hazards and prevention of human life and infrastructure.