Advanced machine-learning approaches for landslide susceptibility map generation using remote sensing data and GIS

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Under the present Indian government initiative, all-weather roads are being taken up for four pilgrimage locations in the Uttarakhand state of India. The Rishikesh to Gangotri road axis is a major road used by local citizens and tourists. Rainfall and numerous anthropogenic activities become the primary reasons for landslide hazards in the area. An accurate Landslide Susceptibility Map (LSM) for any area is of paramount importance for the decision makers of land-use planning. The present study gives a comparative analysis of recent advanced algorithms, i.e. CatBoost, LightGBM and deep neural network topology for generating the LSM by following pixel-based. Fourteen causative factors along with landslide inventory of 154 locations are used for the study. LSM are generated based on JENKS natural break criteria using all the algorithms and their performance comparison is evaluated. Overall accuracy for train and test data, prediction accuracy, area under receiver operating characteristics (AUROC) score for test data, and computational time for model fit on train data; are the criteria used for performance evaluation of each algorithm. In this study, it is observed that LSM can be generated at considerably fast pace if CatBoost or LightGBM is used while deep neural network-based topology gives marginally better results on all other performance measure.

Keywords: CatBoost, deep neural network, landslide susceptibility mapping, LightGBM.

vulnerable to landslides[1]. Over 18,000 people lost their lives due to landslides between 1998 and 2017 in the world, affecting an estimated 4.8 million people[2]. Landslides are caused by various factors, including human-caused activities like mining, development and negative land control, as well as natural phenomena such as rainfall, earthquakes and volcanic activity. Landslides put a heavy toll on communities all over the world[3]. The expanding world population has spurred rapid urbanization and infrastructural development, leading to frequent encroachment in hilly areas. Without adequate planning and control measures, if such anthropogenic activities are conducted at places falling in high and very high susceptible zones of landslide, the results may be a catastrophic slope failure, exposing the region to huge risk.

Amidst these challenges, the mapping of landslide-prone areas has assumed importance in effective land-use management and emerged as an integral component of land management[4–6]. To evaluate and lessen the damage posed by this hazard, relationship of various contributing factors with landslides has been studied[7–9]. Landslide susceptibility map (LSM) provides a way to anticipate landslide-prone areas in terms of probability. It must be considered by the decision-makers in urban development, disaster prevention and defense plans of an offensive/defensive nature in mountain areas.

High-resolution Digital Elevation Model (DEM), Global Positioning System (GPS)