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A rainfall-based warning model for shallow landslides

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According to the statistical data of past rainfall events, the climate has changed in recent decades. Rainfall patterns have presented a more concentrated, high-intensity and long-duration trend in Taiwan. The most representative event is Typhoon Morakot which induced a total of 67 enormous landslides by the extreme amount of rain during August 7 to 10 in 2009 and resulted in the heaviest casualties in southern Taiwan. In addition, the nature of vulnerability such as steep mountains and rushing rivers, fragile geology and loose surface soil results in more severe sediment-relative disasters, in which shallow landslides are widespread hazards in mountainous regions. This research aims to develop and evaluate a model for predicting shallow landslides triggered by rainfall in mountainous area. Considering the feasibility of large-scale application and practical operation, the statistical techniques is adopted to form the landslide model based on abundant historical rainfall data and landslide events. The 16 landslide inventory maps and 15 variation results by comparing satellite images taken before and after the rainfall event were interpreted and delineated since 2004 to 2011. Logit model is utilized for interpreting the relationship between rainfall characteristics and landslide events delineated from satellite. Based on the analysis results of logistic regression, the rainfall factors that are highly related to shallow landslide occurrence are selected which are 3 hours rainfall intensity I3 (mm/hr) and the effective cumulative precipitation Rt (mm) including accumulated rainfall at time t and antecedent rainfall. A landslide rainfall triggering index (LRTI) proposed for assessing the occurrence potential of shallow landslides is defined as the product of I3 and Rt. A form of probability of shallow landslide triggered threshold is proposed to offer a measure of the likelihood of landslide occurrence. Two major critical lines which represent the lower and upper boundaries of the probability range must be defined. The lower critical line (LRTI10) is defined as 10% of rainfall values for the historical rainfall events no matter triggering or not. An upper critical line (LRTI90) is defined as 90 % of rainfall values for all rainfall events exceeded the lower critical line. Further, the various probability of shallow landslide occurrence is analyzed between these two boundaries. Two assessing indexes are used for determining appropriate probability rainfall threshold which are the disaster-capture ratio and false-alarm ratio. The result shows that LRTI70 is preferred adopted as the warning threshold of shallow landslides in this study because of the higher disaster-capture ratio (95%) and lower false-alarm ratio (13%). By the proposed approach, the warning threshold can be determined more reliability and objectivity than the conventional methods (e.g. minimum rainfall threshold or empirical rainfall threshold). The application of the Gaoping River watershed in southern Taiwan was proved that the proposed method can effectively provide early warning before landslides occurred.