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Comparison and applicability of landslide susceptibility models based on landslide ratio-based logistic regression, frequency ratio, weight of evidence, and instability index methods in an extreme rainfall event

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Few researches have discussed about the applicability of applying the statistical landslide susceptibility (LS) model for extreme rainfall-induced landslide events. The researches focuses on the comparison and applicability of LS models based on four methods, including landslide ratio-based logistic regression (LRBLR), frequency ratio (FR), weight of evidence (WOE), and instability index (II) methods, in an extreme rainfall-induced landslide cases. The landslide inventory in the Chishan river watershed, Southwestern Taiwan, after 2009 Typhoon Morakot is the main materials in this research. The Chishan river watershed is a tributary watershed of Kaoping river watershed, which is a landslide- and erosion-prone watershed with the annual average suspended load of 3.6×107 MT/yr (ranks 11th in the world). Typhoon Morakot struck Southern Taiwan from Aug. 6-10 in 2009 and dumped nearly 2,000 mm of rainfall in the Chishan river watershed. The 24-hour, 48-hour, and 72-hours accumulated rainfall in the Chishan river watershed exceeded the 200-year return period accumulated rainfall. 2,389 landslide polygons in the Chishan river watershed were extracted from SPOT 5 images after 2009 Typhoon Morakot. The total landslide area is around 33.5 km2, equals to the landslide ratio of 4.1%. The main landslide types based on Varnes' (1978) classification are rotational and translational slides. The two characteristics of extreme rainfall-induced landslide event are dense landslide distribution and large occupation of downslope landslide areas owing to headward erosion and bank erosion in the flooding processes. The area of downslope landslide in the Chishan river watershed after 2009 Typhoon Morakot is 3.2 times higher than that of upslope landslide areas.
The prediction accuracy of LS models based on LRBLR, FR, WOE, and II methods have been proven over 70%. The model performance and applicability of four models in a landslide-prone watershed with dense distribution of rainfall-induced landslide are interesting and meaningful. Eight landslide-related factors, including elevation, slope, aspect, geology, accumulated rainfall during 2009 Typhoon Morakot, landuse, distance to the fault, and distance to the rivers, were considered in this research. The research builds and compares the difference of the LS maps based on four methods. The average LS value from each method is 0.27 for LRBLR, 0.368 for FR, 0.553 for WOE, and 0.498 for II. The correlation analysis was conducted to identify similarities between the four LS maps. The correlation coefficients are 0.913, 0.829, 0.930, 0.756, 0.729, and 0.652 for the LRBLR vs FR, LRBLR vs WOE, FR vs WOE, LRBLR vs II, FR vs II, and WOE vs II. The research compares the model performance of four LS maps by calculating the AUC value (area under the ROC curve) and ACR value (average correct-predicted ratio). The AUC values of LS maps based on LRBLR, FR, WOE, and II methods are 0.819, 0.819, 0.822 and 0.785. The ACR values of LS maps based on LRBLR, FR, WOE, and II methods are 75.1%, 73.7%, 68.4%, and 64.2%. The results indicate that the model performance based on LRBLR method in an extreme rainfall-landslide event is better than that based on the other three methods.