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Development of Early Warning System for Rainfall-Triggered Landslide Hazard in Taiwan

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The main scopes of this study are to build up event-based landslide inventories, to develop computer codes embedded in ArcGIS 9.X to automatically generate slope units for analysis, to obtain landslide susceptibility factors, and to develop landslide hazard prediction models. The most important purpose is to make landslide hazard maps, based on the slope unit, for early warning before landslide occurring. Four events, Typhoon Mindulle, Typhoon Haitang, 69-heavy rainfall and Typhoon Sepat, were recorded into the event-based landslide inventories by interpretation of satellite images in central and southern Taiwan. The around 60,000 slope units were generated from the DEM of study region. Besides, more than 30 landslide susceptibility factors obtained from GIS were taken into account for landslide hazard prediction analysis.

According to the factor analysis and correlation analysis, 8 factors were selected for development of the landslide hazard prediction models. They are terrain elevation, slope gradient, slope orientation, road development, dip slope condition, lithology, slope topography index, and rainfall intensity. The rainfall intensity is external factor; the others are internal factors. Moreover, the landslide hazard prediction analysis of debris slide was conducted by logistic regression. Finally, the landslide hazard prediction models were established and the slope units on hazard maps were categorized into four landslide hazard levels (high, moderately high, middle, low).

The landslide hazard prediction models were verified by classification error matrix, statistical tests and ROC curves (Receiver Operator Characteristic curves). From the classification error matrix and ROC curves, the accuracy rate of the developed models reaches about 75%. The statistics tests also show that the presented models all reach significant level. Besides, the prediction of landslide occurrence was influenced by the rainfall intensity. The model considering the cumulated rainfall in 1 and 72 hours predicts better than that considering the cumulated rainfall in 1 and 24 hours. However, the model considering the cumulated rainfall in 72, 24 or 1 hours individually has poor prediction ability.

Furthermore, the landslide hazard prediction models were applied for predicting landslide area induced by the events, Typhoon SINLAKU and Typhoon JANGMI in 2008. From the satellite images before and after Typhoon SINLAKU, more than 72% of the new landslide area (high and moderately high susceptibility levels) induced by the event can be predicted. Besides, after site investigation, 7 landslides after Typhoon JANGMI took place and 6 of them located in high and moderately high hazard levels can be predicted. Therefore, the proposed landslide hazard prediction models can be applicable in the practice of landslide hazard mitigation, such as the landslide early warning system.

Keywords: Early warning system, Slope unit, Landslide hazard maps, Susceptibility factors, Logistic regression