Rainfall-Induced Landslide Distribution Characteristics Assessment in Southern Taiwan

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INTRODUCTION

Because of poor physiographic conditions and steep mountainous terrain, concentrated rainfall accompanying typhoons and rainstorms can easily trigger landslides and debris flows in unstable regions. In recent years, because of extreme rainfall events, numerous slope landslides, heavy river siltation, and riverbank dikes have markedly changed the natural environmental conditions of catchment regions in Taiwan.

Slope landslide analyses generally explore primary hazard factors used for identifying the landslide hazard factor combinations and establishing landslide potential assessment models. Although uncertainties continue to exist regarding various hazard factors, and certain challenges are difficult to overcome, these factors provide essential information for estimating the size of potential landslides. Because technological advances afford numerous land use monitoring tools, in post disaster large-area slope disaster interpretation and judgment, aerial photography and satellite images are often used for risk interpretation and assessment.

Our study area covered various parts of the Laonong catchment in Kaohsiung, southern Taiwan. This study applied a GANN in classifying satellite imagery, using the gray level co-occurrence matrix (GLCM) for extracting textural information from high-resolution satellite images to improve assessment and interpretation accuracy. Moreover, GANN and MHEM was applied for quantitatively analyzing the weights of various hazard factors related to natural environmental and slope development to estimate the landslide susceptibility of the study area. Finally, GIS was used to describe the landslide susceptibility diagram and explore the impact of extreme rainfall events on slope landslide and development characteristics of the landslide region.

RESEARCH METHODS

Genetic Adaptive Neural Networks

According to the studies by Chen et al. (2010) and Chen et al. (2013), parameters were optimized using GAs coupled with an ANN; the basic principle involved setting the ANN architecture parameters, including the weighting matrix, as the GA chromosomes (i.e., target solutions). In this study, depending on the GA's ability to determine the optimal solution, a network structure that minimizes the error between the predicted and actual values was determined.

Multivariate Hazards Evaluation Method

MHEM is a measurement-based multivariate nonlinear mathematical model. Using relative relationships, MHEM involves applying a danger index as the risk indicator of environmental hazards in different regions of the study area (Su et al., 1998; Lin et al., 2009).

RESULTS AND DISCUSSIONS

This study focused on the 3 years after Typhoon Morakot (2009 to 2011). During this period, the study area experienced six heavy rainfall events, including five typhoons (2009 Typhoon Morakot, 2010 Typhoon Meranti, 2010 Typhoon Fanapi, 2011 Typhoon Meari, 2011 Typhoon Nanmadol) and one torrential rain (24 hours accumulated rainfall more than 130mm). To provide disaster prevention countermeasure, the disaster potential in study area was analyzed. Furthermore, the assessment model for variation trend of slope land use change and development factors was established. Correlation analysis of regional environmental characteristics was also carried out.

The results show that the 9 potential factors determined by MHEM in decreasing weight ratio order are: geology, effective accumulative rainfall, slope, distance from fault, aspect, degree of slope disturbance, elevation, distance from water system and slope roughness. Through ArcGIS the potential map of landslide probability is plotted to distinguish high potential regions from low potential regions. The agreement of landslide potential map is at 85% level compared with historical disaster sites.

The greater the effective accumulative rainfall (EAR) or landslide potential, the more likely it is that the number and area of bare ground ratio in study area after heavy rain fall events become greater, as shown in **Figures 1** to **3**. Under the different rainfall, the greater the average of EAR, the more the landslide occurrence and area increments. The determination coefficients of trend lines on the charts of the average of EAR versus number and area of landslide increment are 0.83 and 0.92, respectively.

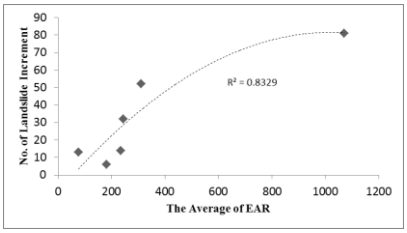

Fig. 1 The average of EAR versus number of landslide increment

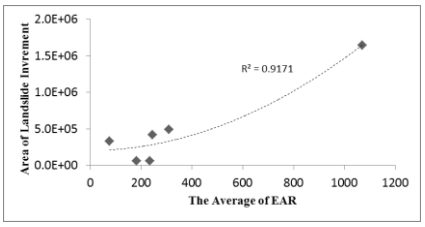

Fig. 2 The average of EAR versus area of landslide increment

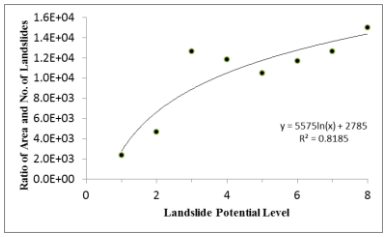

Fig. 3 The relations between landslide potential level and the ratio of number and area of landslide increment

CONCLUSIONS

The research focus on the trend of land use change, degree of slope land development, and human activities in Kaoping River Basin, South Taiwan (Laonong River watershed). Results of image classification show that the values of coefficient of agreement for different time periods are at intermediate-high level. The predicted potential of landslide is in reasonable confidence level. The relations between landslide potential level, degree of land disturbance, and the ratio of number and area of landslide increment corresponding six heavy rainfall events are positive. Furthermore, the relation between the area increment of secondary landslide, average of EAR or the slope disturbance is positive. Under the same slope disturbance, the greater the EAR, the more the area increment of secondary landslide.

The results of the analysis of this study can be a reference for the government for subsequent countermeasures for slope sediment disaster sensitive area to reduce the number of casualties and significantly reduce the social cost of post-disaster.

Keywords: landslide, satellite image classification, artificial neural networks, multivariate hazards evaluation method