Applied Artificial Neural Network in the Spatial Prediction of Landslide Harzads case Study in the Red River Basin, Vietnam

Xuan Quang Truong[1*], Thi Hang Do[2], Xuan Luan Truong[3], Ngoc Hoan Nguyen[1], Chi Cong Nguyen[1]
Anh Duong Quan[3], Thi Thanh Thuy Pham[1], Thi Thu Ha Le[1], Thi Hong Minh Tran[1]

[1]Hanoi University of Natural Resources and Environment,
No 41 A Phu Dien Road, Phu Dien precinct, North-Tu Liem district, Hanoi,Vietna,
Email: txquang@hunre.edu.vn
[2]Osaka City University, Japan
Chome-3-138 Sugimoto, Sumiyoshi Ward, Osaka, 558-8585, Japan.
[3]Hanoi Unversity of Mining and Geology
No.18 Vien Street - Duc Thang Ward- Bac Tu Liem District - Ha Noi

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Abstract: Landslide hazards frequently occur in the upper part of Red River Basin Vietnam causes of and many losses of lives. The main objective of this paper is to evaluate and classify of risk levels of landslides maps base on the important factors causing landslides. Several causative landslide factors such as rainfall, relief amplitude, slop, land cover, soil type, aspect, fault density, drainage density and lithology have been considered. The result presents an account the actual locations landslides that occurred over a period of 18 years in the study area in Lao Cai Province in Red River basin. Landslide susceptibility were estimated under different Geo-Environmental conditions. In this study, Bayesian Regularized Neural Network (BRNN) was applied, results of the model are evaluated, compared and matched to locations where new landslides occurred. The result of the study enabled the validation landslide susceptibility models and significance to the local geo-environmental conditions. The area under the curve (AUC) for the statistical index model was 0.91 for the BRNN model.

Introduction

Vietnam is a mountain country (mountains and hills account for 70% of the territory) and landsides are widespread and recurrent phenomena mainly due to its peculiar geological features, geomorphological patterns and especially, the unfavorable weather conditions associated with tropical climate and rainfalls. The Lao Cai province, located in the Northwest mountainous area and in the upper reaches Red River Basin Vietnam, has been heavily affected by landslides. Investigations of landslide susceptibility analysis have been carried out in study areas by (Bui et al., 2017), (Le et al., 2021) and (Truong et al., 2018). Advances in the applications of ANNs for landslide study were presented by (Lee et al., 2003) and (Bui et al, 2012). They showed that ANNs are not depend on statistical distribution of the data and specific statistical variables. This characteristic allows ANNs to incorporate different types of data into landslide models, ANN can work even when the correlation among landslide causative factors are complex and unknown. This paper presents Bayesian Regularized Artificial Neural Network method (BRNN) in order to produce landslide susceptibility

maps for three years 2000, 2008 and 2018. The landslide susceptibility was processed based on the steps: build data layers (geo-database) based on remote sensing (RS) images and GIS; Those data were used for implementing the ANN model. A BRNN is basically a back propagation network that combines the conventional sum of the least squares error function with an additional term called "regularization", Bayesian was applied to add probability distribution to the weight that preseents the relative degrees of belief in the different values.

Study area

The study area is the upperpart of the Red River in Lao Cai Province where is located in the northwestern part of Vietnam. It covers an area of about 3,273.5 km2 (total area of Lao Cai province is 6,383.9 km2) is the region with specific landslide hazards for the upstream region of the major rivers of Vietnam. The altitude of the area ranges from 48m to 2,812 m. In order to calculate BRNN, 09 factors including: rainfall, drainage, fault, slope, aspect, relief amplitude, landuse and land cover, lithology, soil maps were used as the input data of the model and those data was calculated for year 2021.

Bayesian Regularized Artificial Neural Network

The dataset was devided into 70% for training and 30% for validate model. The maximum number of epochs was set to 1000 and the SSE goal was set to 0.0001. In order to obtain a landslide susceptibility map (LSM), the landslide susceptibility indexes were classified into five different susceptibility classes. The area under the curve of the model is 0.91 and overall accuracy is 80%, this accuracy could be considered satisfactory for landslide susceptibility mapping.

Results and discussion

Landslide susceptibility map was divided into five classes based on standard deviations of the probability histograms, LSM have already showed very low (49.27%) it approximates 1612.84 km^2, low (21.13%) 691.68 km^2, medium (15.39%) 503.78 km^2, high (10.9%) 356.81 km^2 and very high (3.31%) 108.35 km^2. The relative importance of the landslide causal factors in the model, the results show that distance to rainfall, slope, and land cover are the most important factors.

References

Bui T, D.; Tuan, T.A.; Hoang, ND. *et al.* Spatial prediction of rainfall-induced landslides for the Lao Cai area (Vietnam) using a hybrid intelligent approach of least squares support vector machines inference model and artificial bee colony optimization. *Landslides* 14**,** 447–458 (2017). https://doi.org/10.1007/s10346-016-0711-9

Bui T, D.; Pradhan, B.; Lofman, O.; Revhaug, I.; Dick, O.B. Landslide susceptibility assessment in the hoa binh province of vietnam: A comparison of the levenberg-marquardt and bayesian regularized neural networks. *Geomorphology* 2012, 171–172, 12–29.

Le T. T. T., Tran T.V., Hoang V.H., Bui V. T., Bui T. K. T., Nguyen .H. P, "Developing a Landslide Susceptibility Map Using the Analytic Hierarchical Process in Ta Van and Hau Thao Communes, Sapa, Vietnam," *J. Disaster Res*., Vol.16, No.4, pp. 529-538, 2021.

Truong, X.L.; Mitamura, M.; Kono, Y.; Raghavan, V.; Yonezawa, G.; Truong, X.Q.; Do, T.H.; Tien Bui, D.; Lee, S. Enhancing Prediction Performance of Landslide Susceptibility Model Using Hybrid Machine Learning Approach of Bagging Ensemble and Logistic Model Tree. *Appl. Sci.* 2018, *8*, 1046. https://doi.org/10.3390/app8071046.

Lee, S., Ryu, J. H.,Min, K.D., Won, J.S., (2003), Landslide susceptibility analysis using GIS and artificial neural network. *Earth Surface Processes and Landforms* 28, 1361–1376.