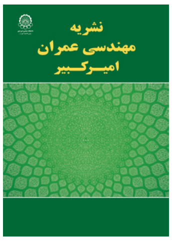

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Comparison Between Selected Experimental Methods And Statistical And Artificial Neural Network For Landslide Hazard Zonation Case Study: Behesht Abad Dam Reservoir

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ABSTRACT: In order to decrease the destructions due to landslides, it's important and unavoidable to recognize and to map the hazard zonations. For this, different mehods were utilized by researchers in other countries with specific conditions. In this paper, landslide inventory map has been prepared and then the effective parameters on the landslides in the study area have been investigated. Finally, some empirical methods such as Mora-Vahrson and Nilson methods with bivariate statistical and Artificial Neural Network (ANN) methods were selected by using comparison of various methods between original locations and this study area in Behesht Abad Dam reservoir.

In consequence of landslide hazard zonation mapping by above mentioned methods, some relations including empirical Probability Factor (P), Landslide Index (Li) and Reciever Operating Characteristic (ROC) curves were used to evaluate the accuracy of each method. Finally, the results of ROC curve and calculation of Area Under ROC Curve (AUC) were based for evaluation of accuracy. Therefore, artificial neural network and statistical methods were selected to provide suitable maps in this area.

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1- Introduction

Different techniques or tools may be adopted with various approaches for determining potentially unstable areas or landslide susceptibility assessment. These techniques can be divided into four groups: expert evaluation, statistical methods, non-deterministic model and mechanical approach [6].

In this paper different approaches for the evaluation of landslide susceptibility models, and for the comparison of their performance were analyzed. Finally the ROC curves (Receiver Operating Characteristic) and the Area Under Curve (AUC) was used to evaluate the accuracy of each landslide hazard zonation map. According to the ROC curves, the best model is the discriminant model with coarse slope units. Statistically, this model is more robust than the others because the proportion of a-priori classified stable and unstable units is almost the same [3].

The study region is the Behesht Abad Dam Reservoir Basin in Chaharmahal and Bakhtiyari Province in Iran. It lies in 31°59′19″ N latitude and 50°36′23″ E longitude and covers a surface area of 222 km^2. Total inventory landslides occurred in region is equal to 1.42 km^2 and in contrast to total area is equal to 0.63% of region. The prevailing constituents of the sedimentary rocks of the basin are limestone, marl and alluvial deposits.

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2- Methodology

The following describes the material and methods for landslide hazard zonation and accuracy of each map produced.

2- 1- Landslide-Influencing Data

Six variables were selected for the landslide susceptibility map study area of the Behesht Abad Basin: lithology, elevation, slope, aspect, daily rain and peak ground acceleration (PGA). These variables were selected because they have been successfully tested in previous studies and it is shown in Table 1. Further layer pre-processing was done in the ArcGIS environment. The data required to produce a susceptibility map of the study area was derived from various datasets.

2- 2- Landslide inventory

The landslide inventory for the Behesht Abad Basin was constructed using aerial photographs and verified by extensive field surveys using the global positioning system. A total of 100 rotational and translational landslides were detected and recorded to use in this paper.

2- 3- Landslide Susceptibility Mapping

In this study four methods were selected for mapping the slope hazards. The following describes a simple explanation of each method:

Mora-Vahrson Method

The Mora-Vahrson method was selected due to similarity of conditions between Behesht Abad Basin and origin region especially high rain. At first, the region was devided in grids with 1 km×1 km and finally a Landslide Hazard Index (H_L) for each unit of grid by using the following formula was calculated and used to produce a map [4]:

$$H_L = (S_r \times S_l \times S_h) \times (T_s + T_p) \quad (1)$$

In above equation, S_r, S_l, S_h, T_s and T_p are roughness sensitivity, lithological sensitivity, humidity sensitivity, seismic tensity and precipitation tensity respectively.

Modified Nilson Method

The most important factors about using the Nilson method are slope and lithology to produce a susceptibility map [4]. By crossing the three maps i.e slope map, slide deposits and units sensitive to failure, finally a map can be produced.

Bivariate Statistical Approach

Bivariate statistical analyses undertake an individual statistical assessment of each factor in relation to landslide occurrence using weights of evidence, certainty factor function or information value method [5]. In this paper, weights of evidence method was used and the Area Density (D) and Area Ratio (R) for each subclass were calculated. At the end of calculation, the weighting maps were crossed together to produce a hazard map.

Table 1: Effect of information layers in Behesht Abad Basin on slope instability

PGA	24 hours rain	altitude	Slope aspect	slope	Lithology	**Effective Factors**
1.4%	17.5%	2.9%	12.1%	24.9%	40.8%	**% of effect**

Artificial Neural Network

An artificial neural network is defined as a computational mechanism that is able to acquire, represent and compute a mapping from one multivariate space of information to another, given a set of data representing that mapping [1]. The back-propagation training algorithm is the most frequently used neural network method, and was the method used in this study. Using the back-propagation training algorithm, the weight of each factor can be determined and used for the classification of data (input vectors) that the network has not seen before [2]. The weights were applied to the study area, and LSI value was calculated.

The network used in this study consisted of three layers. The weights between the layers acquired by the neural network training are calculated in reverse and the contribution or importance of each factor was calculated. Weights that represent the contribution or importance of each factor were determined.

The six factors before mentioned were used as the input data. The factors were converted into 50 m× 50 m cells for the study area. Areas where landslides had not occurred and where the value of the slope was zero, were classified as “areas not prone to landslide,” and areas where landslides were known to have occurred were assigned to the “areas prone to landslide ”training set.

In this study, a 6 × 19 × 1 structure was selected for the networks. The root mean square error value used for the stopping criterion was set to 0.047. The weights were determined after training. The final step of ANN analysis was preparation of the landslide susceptibility map. To achieve this, the trained and tested ANN structure was applied to the derivative data sets and the final landslide susceptibility map of the .study area was produced

2- 4- Evaluation of Map Accuracy

To test the accuracy of each produced landslide susceptibility map, different methods were used. Some relations including empirical probability factor (P), Landslide Index (Li) and Reciever Operating Characteristic (ROC) curves were used to evaluate the accuracy of each method

To quantity the results, a ROC curve for each map was drawn. These curves were obtaind by SPSS software. When the Area Under Curve (AUC) of ROC is close to 1, the best .[accuracy is achieved [3

On the basis of ROC curves, ANN and bivariate statistical mehods had 0.824 and 0.802 AUC values respectively and Mora-Vahrson and Nilson methods had a lower AUC values about 0.71.

3- Conclusion

In this study, ANN and statistical methods were selected as the best in Behesht Abad dam reservoir Basin and they had a very good correlation in ROC curves. Also, the ANN method needs the accurate data for basins similar to Behesht Abad.

In Mora-Vahrson method, because of large size for map units it can be illogicalled to use for regions with inhomogen-.ity in influencing factors

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