Combination AHP and Neural Network Model to landslide Hazard Zonation (Case Study: Bijar)

Hadi nayyeri[1], Mohammadreza Karami[2]

1. Faculty member of Geomorphology department,, Faculty of Natural Recourses, University of Kurdistan.
2. Faculty member of Geography and Urban Planning department, University of Payame Noor

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Extended Abstract

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Introduction

The prediction of landslide occurrence in a region is very important in reducing the risks and damages. As a natural disaster Landslide has caused a lot of life and financial losses to Iran annually. According to the National Committee on Natural Disaster Reduction of the Ministry of the Interior in 1994, the share of annual damage caused by mass movements in Iran is estimated at 500 billion rials. Consiering the occurrence of landslides in Iran Kurdistan province is the third province after Mazandaran and Golestan. Since the area is at a higher level, Bijar has a high potential for a wide range of landslides with a combination of mainly mountain topographical factors, lithologic conditions and positioning between two major faults in the region. In this research, using quantitative methods and models on the quantitative factors of this phenomenon based on the level of information given by past mass movements and influential factors, focusing on artificial neural network method, susceptibility zones were determined by computing the possible risk level.

Knowing such natural events requires proper management of the risks posed by them. On the other hand, artificial neural network as a quantitative model is capable of learning, generalization and decision making, and less need to analyze the accuracy of data in comparison to statistical methods. Map of the susceptibility of the areas to the landslide is an important tool for land use planning. However, there are many issues in the formation of this phenomenon, which, due to the complexity of the natural processes arising from the relationship between the outcome (dependent variable) and the factors (independent variables), puts into question the general zoning of such areas .

Methodology

Bijar is located in the northeastern part of Kurdistan province, along the longitude of 47 ' 29° to 47 ° 47' east, latitude 35 ° 35 'to 35' 59 °north. In recent years, the development of the Geographic Information System (GIS) and spatial analysis techniques have improved the risk of indirect zoning. In this regard, artificial neural networks can cover a significant part of these needs. Implementing the neural network model requires trainingdata. Without trainingdata, making neural networks is virtually impossible. In this paper, trainingdata shows the occurrence of landslides which have geographical coordinates and were obtained from the Kurdistan Natural Resources Organization. In general, trainingdata in GIS and remote sensing can include data or raster, which in this paper is a point phenomenon and has 144 cases . However, because of the wast area under study and the low number of training data, as well as the lack of risk of any landslide zone (from low to very high), the points should be classified in terms of accepted numbers. Also, the number of points with relative values should be normally ditributed both geographically and regarding the number of training data in each class (the classes derived from the results of AHP model). It should be noted that all the maps were standardized in the format of the Raster in a matrix (698 rows in 897 columns) identical with a size of 30 * 30 meters. This means that each map has 626,106 pixels of varying value and somewhat similar. In addition, the AHP model was used to categorize the studied area from very desirable (hazardous) to very undesirable (very dangerous) areas. Also, 33 points were added to the trainingdata on different levels of the map derived from the AHP model. But to verify accurately the model, only landslide occurrences were considered.

In order to find out the factors of landslide in Bijar, a map of slope, aspect, elevation, distance from the fault, distance from the road, distance from the river, drainage density, lithology and land use using ArcGIS software were prepared and digitized.

After compiling and categorizing these variables, at first, each of the effective criteria in the field was divided into six sub-criteria (land suitability for landslide) from very desirable to very undesirable conditions. The present study utilizes the technique of multi-layer propspert neural networks using post-propagation algorithm (BP). In addition to correcting and editing the layers, the neural network model was implemented using the classification method and applying two types of functions (linear and sigmoid). Then, using the test-error method, the study of the magnitude of the error and the period of the repetition and the change in the number of hidden layers and weights, both functions were performed. Finally, the sigmoid function, which yielded a better result, was selected as the proposed and final function. Order to verify the (accuracy) of the map taken with the existing landslide zones, the final map of the neural network model was again transferred to the ArcGIS software. Finally, the available landscapes on the map resulted from the adaptive neural network model, which, by comparison, gave a percentage and amount of accuracy of each class was achieved.

Result

The input layer was calculated to six classes based on the desirability of mass movements. This decision approach reduces the complexity of the network and improves its performance. For this purpose, the AHP method was used to define non-slip pixels and range classification.

To implement this method, nine variables discussed, were scaled up to the most suitable and un-suitable range. The final weight of these variables was obtained by using the Thomas saati pair comparison (Table 4), the study area was divided into five categories according to the map for land suitability for landslide hazard. From each class, the 20-pixel from AHP model was selected for network trainingin a completely randomized manner. The proposed model is an artificial neural network of MLP multi-layered perceptron with levenberg-marquardt trainingalgorithm. An early stopping method was used to improve network optimization. Several hidden layers were tested to find the best results. It should be noted that in the structure of all networks, at least the optimal design with the middle one is used, but in their structural composition they are also used with mid-duplex networks. In this paper, the use of tow mid-layers showed better results. In all simulations performed in the neural network model, the mean square error index was considered as a critria of the efficiency and accuracy of simulations. By changing the number of intermediate neurons and changing the weights as try and error, the most appropriate network model was obtained for the purpose. In this study, the structure of the network with 9 input layers, 2 hidden layers, 1500 repetitions in both functions was accepted as the final structure. The main structure of the neural network with two linear and sigmoid functions was prepared with acceptable error, and the study area was analyzed with a total area of 564 km^2 with 9 input variables converted into raster data to 30 × 30 pixels. From 564 km^2 based on the sigmoid function 61.17% and based on the linear function, 72.76% of the area is unsuitable and very unsuitable in the area where expose to high risk. In both networks, there were very few areas in both optimal and moderate classes (Figures 16 and 17), which indicate the high talent of the area for landslide as a threat. Then, ArcGIS software was used to evaluate the efficiency and accuracy of the model. For this purpose, the point of landslide and zoning maps were combined, compared and analyzed. The results showed in the sigmoid function 75 items of landslides were in a very unsuitable range, which included 61% of the total of region.

Conclusion

In the linear function, approximately 69% of the landslides are in a very unsuitable range and the unsuitable results are about 57%, which results in the success of the model designed in the neural networks (MLP). In the end,

the network with sigmoid function is negligibly better than the linear function network. The results show that Bijar and its functions are relatively prone to occurrence of landslides, so that nearly 60% of the city's area is a high risk area with a high risk and only 2% is a low-risk region. The hazardous areas are mainly located around the city of Bijar especially southern and southeast. These areas correspond to high altitudes and maximum fault density and lime lithology with marl (Qom Formation). The model can be very challenging, because of innovative nature of the research that means needs more detailed and comprehensive studies.

*Corresponding Author: nayyerihadi@yahoo.com