Examining Landslide Hazard Zonation in Ispiran, East Azerbaijan Province Using Logistic Regression Model and GIS

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1 Introduction

Landslide is one of the natural hazards caused by multiple factors such as topographic conditions, tectonic activity, climatic conditions and the vegetation of the area. This phenomenon may have many financial and human losses. Landslide hazard may include the degradation of natural vegetation, the degradation of roads and residential buildings, soil erosion, increasing sediment loads, and, most importantly, casualties.

The country of Iran with its mostly mountainous topography, tectonic activity and high seismicity, diverse climatic and geological conditions possesses major natural conditions for the occurrence of a wide range of landslides. Therefore, planning to prevent these losses or at least reduce them is very important and will prevent the loss of national funds. One of the effective solutions to reduce landslide losses is to provide a zoning map, determine the sensitivity of different areas to the occurrence of landslide and identify the high-risk areas. By using hazard zonation maps, it is also possible to identify safe locations for the development of new habitats and settlements and other land-uses such as roads, power transmission lines and power plants at different scales. So far, a large number of quantitative and statistical methods have been used to assess the probability of landslide occurrence and prepare zoning maps.

For example, a variety of statistical models such as logistic regression, analytic hierarchy process (AHP), analytic network process (ANP), artificial neural network (ANN), and fuzzy logic model have been widely applied to create hazard maps.

In this study, a landslide hazard zonation map is prepared for Ispiran in East Azerbaijan Province, Iran, where several landslides have been undergoing in the past. The entire study area is classified into five classes according to the risk of landslide occurrence.

2 Materials and Methods

In this study, logistic regression (LR) model and geographic information system (GIS) were used to prepare a landslide sensitivity map. The study area is Ispiran which is a rural district in the central district of Tabriz County in East Azerbaijan Province, Iran. This

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area is located in the Urmia basin with an approximate area of 660 km2, 38° 1'N to 38°, 28'N and 46° 14' to 46°27'E.

Logistic regression model is applied to determine the relationship between a dependent variable and independent variables. The procedure is quite similar to multiple linear regression, with the exception that the dependent variable is binomial. In this study, the absence or presence of landslide is considered as dependent variable of the model and affecting factors are entered to the logistic regression model as independent variables. Data set of landslides of the area as well as the maps of the affecting factors including elevation, slope, aspect, land use, geology, rainfall, distance from the roads, distance from the rivers, distance from the fault and distance from the settlements were prepared using topographic maps of scale 1: 25000 and digital elevation model (DEM). After determining the factors affecting the occurrence of landslide in the studied area, the relevant data layers were prepared in the GIS environment. In order to determine the coefficients of logistic regression model, the maps of the distance from the rivers, elevation, precipitation, distance from the road, geology, slope, aspect, land use, distance from the fault and distance from residential areas were standardized and then entered to logistic regression model as independent variables. In this way, the role and relative importance of each of the factors was determined in landslide occurrence. Data layer of past landslides was considered as dependent variable of regression model. In the following, the results of the logistic regression model were evaluated.

The results of regression model were evaluated using Chi Square, Pseudo R Square and ROC measures. The Pseudo R Square index based on the likelihood ratio principle tests the goodness of fitting into the logistic regression. The Pseudo R Square can range from zero to one, the higher pseudo R-squared indicates which model better predicts the outcome.. In spatial studies, Pseudo-R square more than 0.2, can be considered as a relatively good fit. The efficiency of the susceptibility model can be evaluated by ROC index (relative operating characteristic). This index is computed from the ROC curve. The ROC curve is a diagram in which the pixel ratio that is correctly predicted the occurrence or nonoccurrence of landslides (True Positive) is plotted against the supplement amount (i.e. the pixel ratio which is wrongly predicted). Finally, Pearson chi-square is the main test used to determine the significance of the relationship between different categorical variables.

3 Results and Discussion

Previous studies have shown that several factors play a role in landslide occurrence, and most of them are common in different regions; however, the role and importance of each of them in the occurrence of this phenomenon may vary in different regions. According to the coefficients obtained by the model in this study, geology is the most important factor affecting landslide occurrence in the study area. The second affecting factor is land-use.

The model is validated through three measures, including Chi Square, Pseudo R Square and the area under the curve. The results of validation of model are discussed in the following. The value of the Chi Square index is 18.6633, which shows that all coefficients are not zero. The value of the Pseudo R Square indicator is 0.265, which shows an almost

acceptable fit of the model. The area under the curve (ROC) is 0.957, which indicates that the observed landslides have a strong correlation with the probability values derived from the logistic regression model.
Finally, based on the best equation between effective factors, landslide hazard zonation map was prepared for the study area. According to the landslide susceptibility, the whole area was classified into five risk classes (very low, low, moderate, high and very high). The results of the research show that ten percent of the area is located in the high and very high risk classes.

4 Conclusion

Preparing a map of the susceptibility of areas to landslide and determining the probability of its occurrence can play an important role in reducing the hazards caused by this phenomenon. In this study, the integration of logistic regression model with GIS was applied for landslide susceptibility mapping in Ispiran, East Azarbaijan Province, Iran. According to the results, the relative importance of geology and land use is more than other affecting factors in this area.

Keywords: Landslide, GIS, Logistic regression, Zoning, Ispiran

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