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Zoning the Risk of Slope Instability in Garmi City by Fuzzy ANP Method

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Abstract

One of the first and necessary measures to manage slope instabilities and reduce the damage caused by them is to prepare a risk zoning map of slope instabilities and identify areas at risk. The aim of this study is to zoning the risk of slope instability in Garmi city using fuzzy ANP model. For this purpose, maps of factors affecting the occurrence of slope instabilities (slope, slope direction, elevation, lithology, distance from fault, soil, land use, vegetation index, distance from the road, rainfall and distance from the river) were prepared in ArcGIS software environment. . To implement the fuzzy ANP model, all 11 factors were involved and the desired network was formed. Criterion weighting was performed in a network analysis model using a questionnaire. By combining the obtained weights obtained from Supercision software with the relevant layers in ArcGIS software environment, the final map of fuzzy ANP model was obtained. As a result, the zoning map provided the risk of slope instability with good accuracy.

Data and method

A) Hydrological data; Includes rainfall data, surface water data, and groundwater potential data. Statistics and information about this data are obtained from meteorological stations in the region.

B) Geological map of the study area with a scale of 1: 100000 which includes information about lithology, geology and tectonics. This map can be prepared from the entire surveying organization of the country.

C) Digital model height 30 meters (DEM); Available from the US Geological Survey's Global Observatory site and used to provide slope layers, slope direction, height and density of waterway networks.

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Fuzzy function

Fuzzy theory was presented by Lotfizadeh in 1965 in an article entitled "Fuzzy Collections" in the Journal of Information and Control (Ilanloo et al., 2010). And facilitated the analysis of unbroken natural processes or phenomena (Rajami et al., 2010). The fuzzy logic model is an extension of the classical theory of sets in mathematics. And is a new way to express everyday uncertainties and ambiguities (Abedini and Fathi, 2014). Lotfizadeh's definition of fuzzy logic is a fuzzy set refers to a kind of classification method in which the boundary between different classes is indeterminate. In fact, the transition from one class to another is gradual and slow. The elements of each class also belong to each class with a certain degree of membership. Lotfizadeh determined the degree of membership of the elements of a collection in the real world, uncertain, and its value from zero to one. In this case, the degree of membership belongs to the distance (1 and 0) and the function that indicates the degree of membership of each element of a set, is called the membership function (Sadeghzadeh Sadat, 1395; quoted by Rasouli, 1393). One of the advantages of the fuzzy model is that in this case the weight of the factor is not determined with certainty; Rather, only the probability of the weight being presented will be greater than the probability of the other numbers close to it being correct. Another advantage is that because weighting and studying the effect of qualitative factors on the occurrence of mass movements in practice, it faces problems. Fuzzy sets can be used to quantify the effect of various qualitative factors. Of course, this method faces problems such as unreasonable increase in weights, length of calculations and the correct choice of model building. With the development of research and computer technology and the use of appropriate algorithms, it is possible to solve these problems (Ilanloo et al., 2010; Cream, 2001). Fuzzy theory has a high degree of flexibility, because compared to binary methods, it has two values of zero and one (fuzzy logic allows a pixel to belong to several classes based on the degree of non-zero membership).

Network Analysis Process (ANP)

The process of network analysis was developed by Saati in 1971 with the aim of structuring the decision-making process according to a scenario and influenced by multiple independent factors. The network analysis process has all the positive features of AHP, including simplicity, flexibility, the application of quantitative and qualitative criteria simultaneously, and the ability to examine compatibility and judgments. Consider the hierarchical structure (Amira Ahmadi et al., 2015). ANP not only does not impose a mere hierarchical structure on the problem, but also models the problem using a system with a feedback approach (Sadeghzadeh Sadat, 2016). The ANP process is the only mathematical theory that allows the study of different types of interactions, dependencies and feedback systematically (Rustaei et al., 2014). The reason for the success of this

method is how to extract judgments and use mathematical measurement operations to measure relative scales. Preferences (as relative scales) are convincing numerical bases that guide the initial computational operations in a meaningful way. Therefore, the power of ANP is based on the use of relative scales to control all interactions, to accurately predict and make appropriate decisions (Rustaei et al., 2014).ANP can be summarized in four main steps:

Step 1) Build the model and turn the issue / topic into a network structure

Step 2) Formation of pairwise comparison matrix and determination of priority vectors

Step 3) Formation of a matrix (decision matrix)

Step 4) Calculate the final weight vector

The natural solution for making comparisons in cases of uncertainty is to use fuzzy comparisons that model the states of ambiguity in comparison. In other words, the use of fuzzy sets is more compatible with linguistic and sometimes ambiguous human explanations, and therefore it is better to use fuzzy sets (using fuzzy numbers) to make long-term predictions and decisions in the real world. Fuzzy network analysis process is obtained by combining fuzzy hierarchical analysis process and matrix effects of interdependence between criteria.

Discussion and Findings

In order to implement the network analysis model, after preparing a questionnaire and forming a matrix in Excel environment, the data were entered into superdision software. For this purpose, 11 mentioned criteria were selected and divided into 4 clusters or main categories of topographic, geological, land cover and hydrological factors. In Supercision software, the communication network was plotted, the weights of criteria and factors were calculated, and in ArcGis software, the database was created and the weights of criteria were applied, and finally the domain instability risk zoning was performed.

Fuzzy standardization

In this part of the present study, each criterion is standardized using the Fuzzy member ship command, which is a fuzzy logic function in the ArcGis software environment. For this purpose, all the effective factors in domain instability were scored based on the appropriate Weber function in terms of the impact on the occurrence of domain instability between 0 and 1. Each of these factors, depending on their type of operation, follows a specific function, and the fuzzy membership function may be linear, incremental, and decremental. . . Be. The polygon vector layers also become fuzzy after being converted to a raster layer in the same way. After all the layers have been prepared with a common coordinate system, and after weighing the criteria and performing the mentioned

functions for each factor, the result is obtained as maps that show the value of the criteria between zero and one. In fact, the main purpose of implementing the model is to obtain the final weights of each criterion.

Conclusion

Land use, vegetation and slope were the most effective layers for zoning the risk of slope instability, respectively.

Keywords: Zoning, Slope instability, Garmi city, Fuzzy ANP, Super decision