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NATURAL DISASTER PREVENTION AND RISK REDUCTION

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DETERMINATION OF WEIGHT FACTORS AFFECTING SLIDING HANDLING USING NEURON NETWORK

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Abstract

In recent years, landslides have occurred in Vietnam with increasing frequency, intensity, and density, causing great and more serious damage. The article has used the model of artificial neural networks to evaluate the relationship between the likelihood of geological catastrophe occurrence and related environmental factors. The research results in Que Phong district, Nghe An province, allow the establishment of diagrams of the risk of landslides in the study area with predicted reliability of 93.37 %. At the same time, the research results also allow the weighting of each factor in the neural network to be determined, in which terrain elevation, river density, and fault density are three factors that play important roles in the risk of landslides in the study area. The results achieved show the effective application of multi-layer neural network structure in zoning, identifying the risk of landslides, as a basis for orientation and planning for sustainable economic - society development of the study area.

Keywords: Landslides; Geological hazards; Weight factors; Neuron network.

1. Introduction

Geological hazards can be understood as geological phenomena, or related to geology, occurring naturally or caused by humans; Endanger or potentially endanger human life and property. Types of geological catastrophes such as earthquakes, volcanoes, tsunamis, landslides, flash floods, mud floods, and erosion are more and more common, with increasing intensity and more frequent. On the territory of Vietnam, geological catastrophes have caused serious damage to socio - economic, human life, and the environment. According to statistics, only the damage caused by landslides and debit flow in the past 10 years have made 913 people dead. Areas such as Lai Chau town, Dien Bien Dong town and Muong Lay have to be permanently relocated. Many residential areas, works and important economic focus are always on alert. In fact, it is required that any country in the process of socio-economic development must always be associated with the study to avoid risks caused by natural disasters, including Geological variables caused.

Que Phong is a mountainous district of Nghe An province and is one of the areas frequently affected by various types of geological hazards, especially landslides in areas of industrial exploitation and transportation. The study area is about 1,895 km^2 and is located about 180 km distance to the Northwest of Vinh city (Figure 1), within the geographical coordinates 19^{o}26’ ÷ 20^{o}00’ North latitude and 104^{o}30’ ÷ 104^{o}10’ East longitude. Que Phong district is characterized by a largely divided terrain, with 70 % of the natural area being hills and mountains and a dense network of rivers and streams. There are many faults and many unfavorable geological factors. The phenomenon of landslides is common, increasingly large scale, especially during the rainy seasons. The average annual rainfall in the area is 1,800 mm and is distributed seasonally. The number of heavy rainy days, on average, is over 190 days/year. The rainy season starts in May and ends in October, with a concentration of 70 % to 90 % of the annual rainfall, often causing floods, flash floods, pipe floods, and a stimulus for the slippage phenomena. The dry season lasts from November to April of next year, with low rainfall often causing water shortages and droughts in some areas. The recent survey results (November 10th, 2018) show that the phenomenon of landslides in the study area is quite common and in many different forms, such as landslides and flat slides on the rock slope surfaces, rotating and sliding rock mud mixed slopes on soil slopes and rivers and streams (Figure 1).

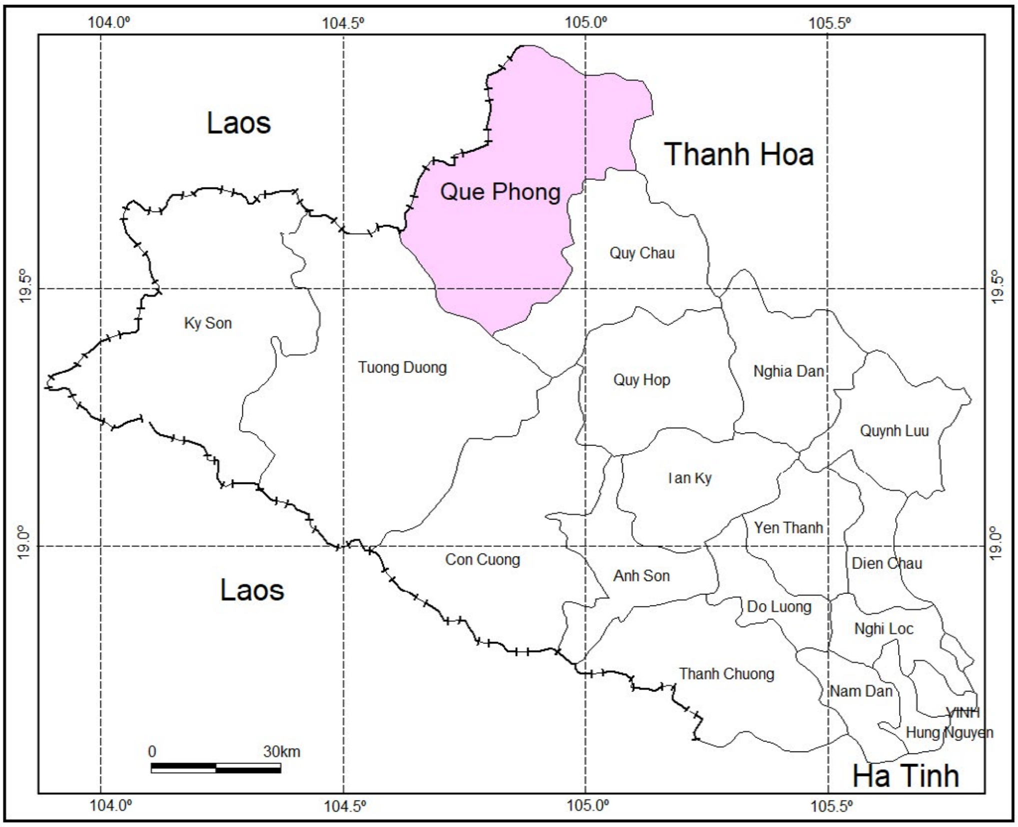
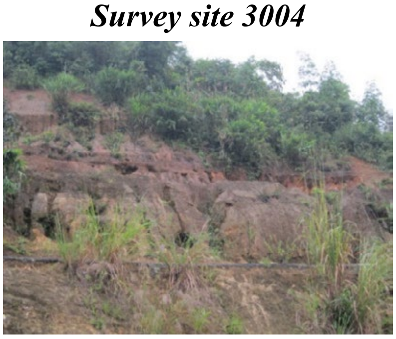
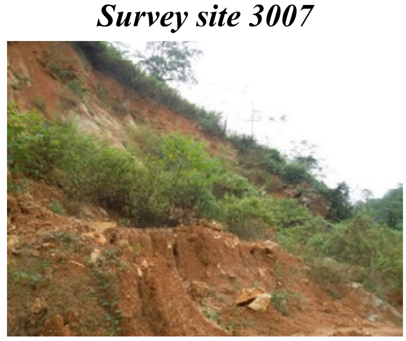


Figure 1: The study area belongs to Que Phong district, Nghe An province

Survey site 3004 ***Survey site 3007*** ***Survey site 5001***





Survey site 5002 ***Survey site 6002*** ***Survey site 6016***

Figure 2: Some pictures of landslides in the Que Phong district

2. Methods

2.1. The factors affect landslides

The phenomenon of landslides is influenced by many factors such as topography, geomorphology, geological structure, petrographic composition, as well as natural and human conditions, making the equilibrium condition of rock mass on the slopes destroyed [1, 2]. The main factors affecting the sliding phenomenon include Geological factors, which are in group of the most important factors. For example, it is the foundation for destructive activities leading to landslides. The main factors include the composition of bedrock, structure and lying position of rock, characteristics of weathered crust, hydrogeological conditions, and engineering geology. Topographical and geomorphological factors: In most cases, the slope is the main cause of landslides. In addition, the terrain conditions are high, with strong cleavage, creating geomorphic energy. A large shape is also a favorable condition for landslides of gravity origin [3]; Meteorological and hydrological factors: Water is almost directly or indirectly related to landslides and is the main factor controlling the occurrence of mass movements. The role of water can be immediately seen in the fact that most landslides occur during or immediately after a period of heavy and prolonged rain; Factors of vegetation: Vegetation is a curtain to limit rainfall falling on steep peaks, creating favorable conditions for water infiltration into the soil. Plants with a root system create cohesion of materials on steep slopes. Besides, the vegetation also adds weight to the slope; The time factor: The resistance of the slope often changes over time. The safety factor of the slope foot often decreases over time due to the long-term concentration of water, strong weathering processes, and reducing the strength of the rock and slopes that can slip after many years; Human activities: Human activities such as watershed deforestation, mineral exploitation, construction of works, transportation, construction of water reservoirs are also important factors to change the natural conditions, causing erosion to be stimulated and occur more frequently [4].

2.2. Artificial neural network model

The artificial neural network model is used to study the relationships between the sliding phenomenon and related factors. A neural network is a design using mathematical models to "mimic" brain activity. Each neural network is a computational model that contains capable processing units of communicating by sending signals to each other through weighted links [5]. The multi - layer neural network architecture is one of the most used architectures to date. The idea of a multilayer network architecture is simulated as shown in Figure 3 below:

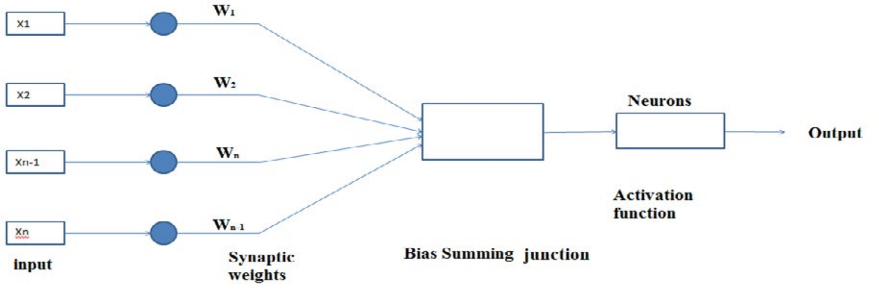


Figure 3: Multi - layer neural network structure

To create a neural network, the original data will be divided into 02 parts, including the training data set to build the model (training set) and the data set to test the model (testing set). A neural network consists of a series of processing "units" that are interconnected like human nerve cells. The network will consist of 03 layers: An input layer, an output layer and a hidden layer. With the input and output transformations, the neural network is trained to initiate the "learning" process (Figure 4).

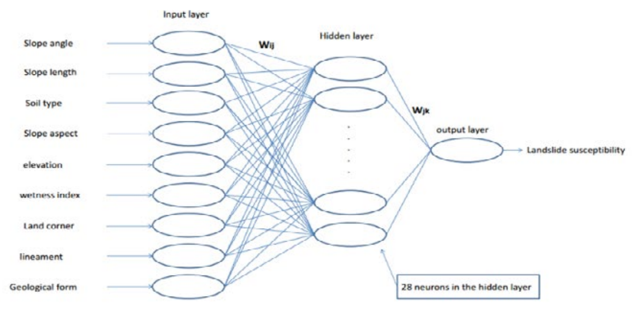


Figure 4: Artificial neural network structure analyzed for landslide

The neuronal learning process is described by the function of the action (or activation function). If the received value (the sum of the multiplied signals) exceeds a certain threshold, this neuron activates (sends signals to the next neurons), and each signal is assigned a weighted corresponding *w* [6].

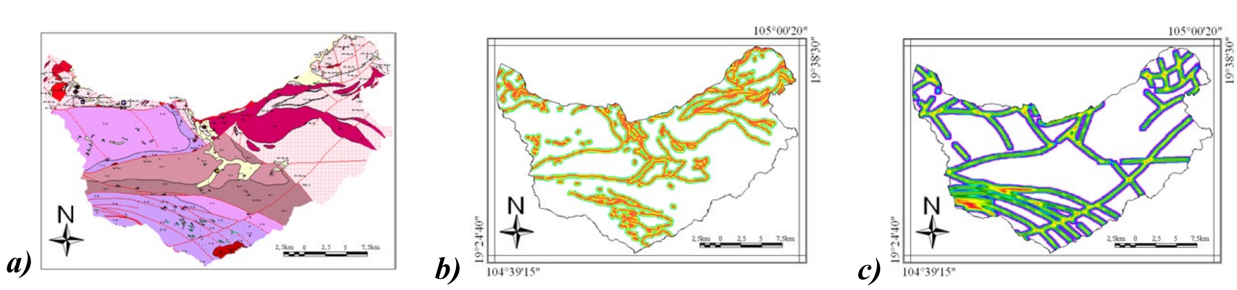
3. Results and discussions

3.1. Creating a database of influencing factors

Determining the causes of a landslides is very difficult because slides are rarely caused by a single cause, so the analysis is often based on a combination of information layers. Based on the assessment of environmental components related to landslides from the results of field survey in the study area and collected documents, the influencing factors related to landslides are separated into 02 main groups:

- Group of geological elements (background elements) including petrographic characteristics, the density of fissures and faults, weathered crust conditions, hydrogeology, and engineering geology (Figure 4).

- The group of natural and human factors includes topographic elevation, terrain slope, river network, traffic density, and population density (Figure 5).



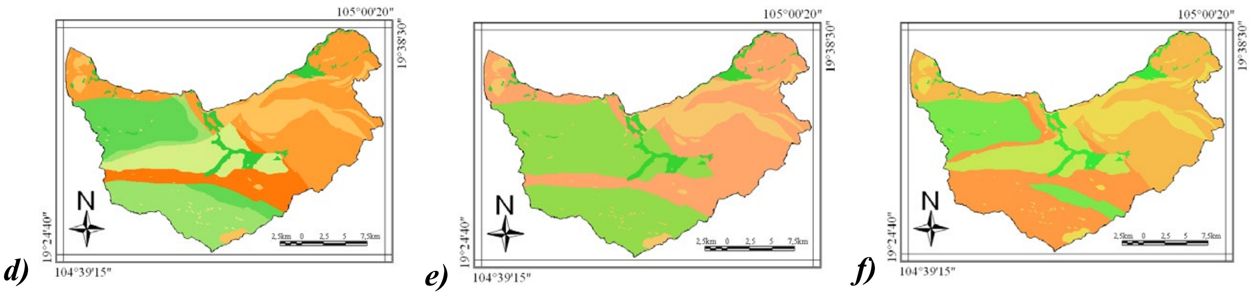


Figure 5: Geological influencing factors: a) Geological conditions; b) The boundary of geological hierarchies; c) Fracture density; d) Engineering geological conditions; e) Hydrogeological conditions; f) Weathered shell condition

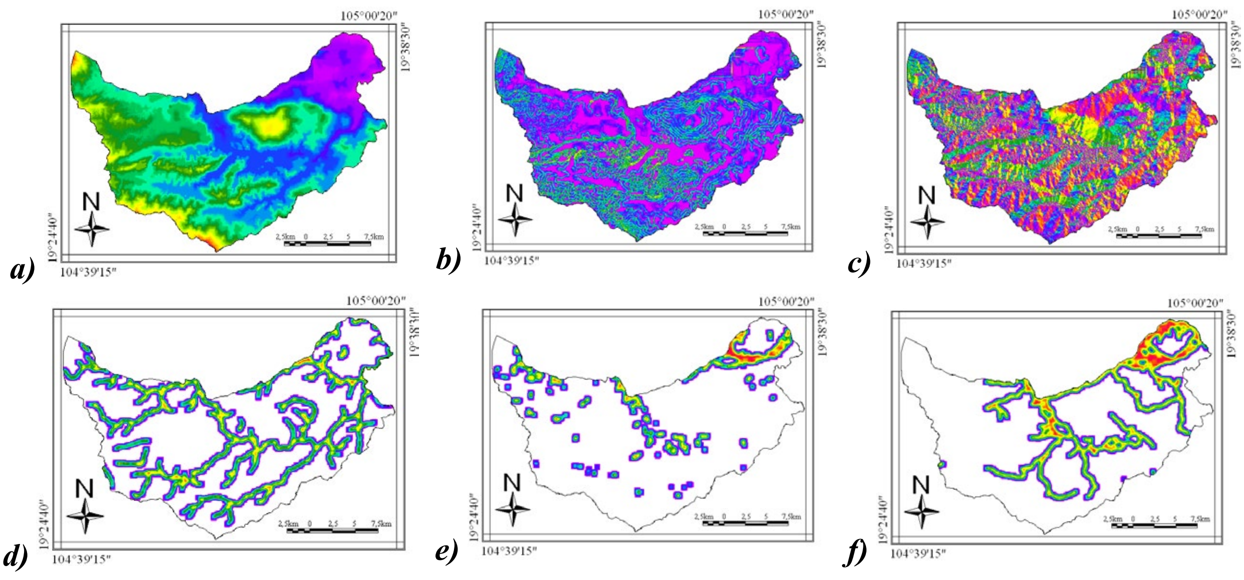


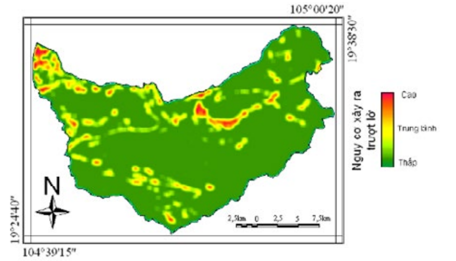
Figure 6: Natural and human conditions: a) Topographic elevation; b) Topographic slope; c) Topographic slope direction; d) Density of rivers and streams; e) Population density; f) Traffic density

3.2. Creating an artificial neural network model to analyze landslide

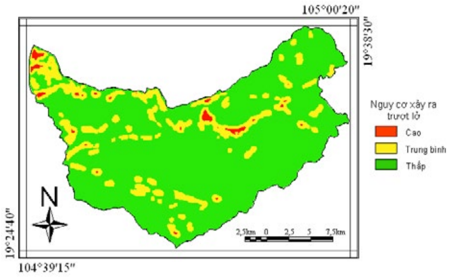
The landslide prediction models are created in terms of the probability of a slide event occurring. The probability of a landslide event is the possibility of a slide occurring in a particular area based on the analysis of the relationship between the occurrence of the slip point and the factors associated with it. Basic information layers such as bedrock distribution, rock structure and lying potential, fracture density and area, hydrological network, terrain elevation, slope, slope direction, and weathering thickness are included in the calculation models, and the results are presented in the form of a network (artificial neural network) [7].

In the study area, the input parameters were used to model neural networks and tested with many different network designs. The results showed that the neural network has a 12×7×2 form for the highest accuracy. The input of the network has 12 nodes corresponding to 12 influencing factors, the output layer is the value indicating the possibility of slip (slip and non-slip). The number of hidden layers is equal to the average of the number of input and output layers.

The results are converted into a digital form of the likelihood of sliding (slip/non-slip) for each specific point (pixel) and linked to represent on the GIS platform into a hazard diagram map). The results allow us to establish the distribution map of landslide risk in the study area (Figure 7).



a)



b)

Figure 7: Map of risk of landslide in Que Phong district, Nghe An province
a) Probability of landslide; b) Hierarchy of landslide risk

The training (learning) of the neural network, in fact, is the process of finding the weights so that the smallest error occurs. The weights in each neuron link are communicated automatically, adjusted and returned to the most stable values. Therefore, the final weights in the neural network are the numbers that reflect the importance of each component to the risk of landslides. From the model of artificial neural networks built for the study area, we can separate the weights of each factor as described in Table 1.

Table 1. The weights of each factor in the artificial neural network

Risk factor	Weight	Risk factor	Weight
Terrain elevation	9,326	DCCT = BR	0,543
Slope	2,267	DCCT = LKC1	1,801
The slope direction of the terrain	-4,738	DCCT = LKC2	-0,905
The density of rivers and streams	7,025	DCCT = LKC3	0,261
Lithological composition = Bu Khang	1,275	DCCT = LKC4	0,455
Lithological composition = Ban Chieng	0,346	DCCT = LKC5	0,022
Lithological composition = Q	0,469	DCCT = LKC6	1,320
Lithological composition = Huoi Loi	0,090	DCCT = LKC7	0,028
Lithological composition = Nam Can	0,191	DCTV = CN1	0,493
T Lithological composition = DongTrau	0,390	DCTV = CN2	-0,058
Lithological composition = PZ1	4,732	DCTV = KCN1	-0,136
Lithological composition = Nam Giai	0,038	DCTV = KCN2	0,816
Lithological composition = Gb	0,459	VPH = VPH1	0,476
Lithological composition = MachTA	-1,115	VPH = VPH2	1.807
Lithological composition = Song Ma	-1,643	VPH = VPH3	0,221
Boundary distance DC < 100 m	4,855	VPH = VPH4	-0,081
Boundary distance DC = 100 - 200 m	1,611	VPH = VPH5	1,257
Boundary distance DC = 200 - 300 m	2,256	VPH = VPH6	-1,421
Boundary distance DC > 300 m	-7,500	Population density	-5,330
Fracture density	7,977	Traffic density	-0,161

Based on the results of weight analysis from the artificial neural network model, it is possible to evaluate the importance level of each factor. Specifically for the study area, the factors that have the strongest influence on the possibility of landslides include elevation and terrain slope, the density of rivers and streams, the density of faults, and the rocks of the complex. Especially, terrain elevation, river density, and fault density are three factors that play an extremely important role in the risk of landslides in the study area.

4. Conclusions

The application of modern algorithms to study environmental problems in general and geological hazards, in particular, is getting more and more noticed due to the quantitative nature of the calculated parameters and results. The research results have shown that the current situation of landslides depends on a lot of factors, of which terrain elevation, the density of rivers and streams, and the density of faults are 03 factors that play a very important role in the risk of landslides in the study area. Geological parameters, hydrological conditions, structures, weathered crust, and human conditions have no differences. However, the analytical results also show the relative influence level of each ingredient. The research results using artificial neural networks have helped to identify areas at high risk of landslides as a basis for orientation and planning for sustainable socio - economic and environmental development of the study area.

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