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Risk Analysis of Debris Flow hazardsin Yanbian Prefecture Based on Information Quantity Method

Risk Analysis of Debris Flow hazardsin Yanbian Prefecture Based on Information Quantity Method

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Abstract. Taking the Yanbian Prefecture as the study area, this paper selects 8 influencing factors: elevation, slope, slope direction, precipitation, river, lithology, fault and land use. Taking 163 debris flow points as sample data, information quantity method and GIS platform are introduced to calculate the information amount of each influence due to sub classification. The risk assessment and analysis of debris flow were carried out, and the risk assessment and analysis map of debris flow in Yanbian was drawn. The results show that the areas where the debris flow hazard is more dangerous are in good agreement with the historical debris flow, and the accuracy of the methods and factors used in this paper is verified.

1. Introduction

Debris flow is a natural geological phenomenon peculiar to mountain area. It is a special flood with a large amount of solid matter, such as mud sand and stone, formed by precipitation. It broke out suddenly, and lasted for a short time, coming fiercely, with great destructive power. It is extremely harmful to people's lives, property and transportation facilities. Yanbian Prefecture is located in the border between China and Korea. There are many kinds of geological disasters and frequent hazards in the state, which have an important impact on the Geopolitical Security of the country. The evaluation of debris flow susceptibility can effectively reduce the losses caused by debris flow disasters. In recent years, scholars at home and abroad have carried out a great deal of research on the vulnerability assessment of debris flow. The evaluation models of debris flow hazard are evaluated by analytic hierarchy process, regression prediction model and artificial neural network model, but there are some limitations and shortcomings in each method. The physical meaning of the information quantity model is clear, and the evaluation factors can be classified scientifically. Therefore, this paper uses the information quantity model to evaluate the vulnerability of the debris flow disaster in Yanbian Prefecture. On the basis of the field investigation of debris flow in Yanbian, 8 Influence Factors of elevation, slope, slope direction, precipitation, river, stratum lithology, fault and land use are selected, and the GIS based information model is applied to the assessment price of debris flow in Yanbian Prefecture, in order to prevent and control debris flow in this area. The planning provides the basis.

2. Information Quantity Model

The information quantity model is a model which uses the concept of information entropy to analyze the susceptibility of various factors to geological hazards. The theoretical basis is information theory, which is an effective method for the prediction and evaluation of regional geological disasters. In terms of debris flow disasters, the reduction of debris flow in the process of debris flow indicates the possibility of debris flow disasters. The greater the amount of information, the greater the possibility of debris flow disasters.

$$I(y, x_1x_2 \ldots x_n) = \log_2 \frac{P(y \mid x_1x_2 \ldots x_n)}{P(y)} \tag{1}$$

$$I(y,x_1x_2 \cdots x_n) = I(y,x_1) + I(y,x_2) + \cdots + I_{x_1x_2 \cdots x_{n-1}}(y,x_n) \tag{2}$$

Formula: $I(y, x_1x_2 \ldots x_n)$ is information quantity for debris flow caused by influence factors $x_1x_2 \ldots x_n$.; $P(y \mid x_1x_2 \ldots x_n)$ is the probability of occurrence of debris flow under the condition of influencing factors combination $x_1x_2 \ldots x_n$; $P(y)$ is the probability of the occurrence of debris flow; $I_{x_i}(y, x_2)$ is information quantity fordebris flow caused by x_2 under the influence factors x_1 .

Each factor is calculated separately, and the amount of information provided for the occurrence of debris flow disasters can be estimated by using frequency in actual calculation.

$$I_i(y, x_1x_2 \cdots x_n) = \ln \frac{N_i / N}{S_i / S} \tag{3}$$

Formula: S is the total number of evaluation units in the study area; N the total number of units distributed in the area with debris flow disasters; S_i is the number of units containing evaluation factors x_i in the study area; N_i is the number of specific categories debris flow disaster units which belongs to the factors x_i .

After obtaining the information value of each unit under all the influence factors, the total information value in a single evaluation unit can be obtained by summation.

$$I = \sum_{i=1}^{n} I_i = \sum_{i=1}^{n} \ln \frac{N_i / N}{S_i / S} \tag{4}$$

Formula: I is total amount of information of the unit; I_i is the amount of information of evaluation factors x_i ; N is the total number of selected evaluation factors

The total information value I of the evaluation unit is used as a comprehensive index to determine the unit's effect on debris flow: I >0, the unit is beneficial to the formation of debris flow, and the greater the I value, the higher the degree of susceptibility; when I <0, the unit is not conducive to the formation of debris flow, and the smaller the I value, the lower the degree of susceptibility.

3. The Status of the Research Area

Yanbian Prefecture is located between North latitude 41°59′～44°30′, east longitude 127°27′～131°18′. Located in the Changbai Mountain area, the mountainous area accounts for 54.8% of the total area of Yanbian, The climate belongs to the humid monsoon climate in the middle temperate zone. The main features are dry and windy spring, warm and rainy summer, cool autumn and little rain, and long winter cold season. Factors such as extensive mountains, abundant rainfall, windy and large temperature difference in Yanbian area provide favorable conditions for the formation of debris flow. The terrain of the study area is undulating, and the area of mountain and hilly area accounts for about 70% of the study area. The range of elevation ranges from 15m to 2800m. The slope is mainly between 0°～40°.This terrain and landform is beneficial to the formation of debris flow.

4. Vulnerability Assessment of Debris Flow

4.1. Evaluati Index Status Classification

The spatial analysis function of ArcGIS is used to superimpose the distribution relationship between the influence factors and the debris flow hazard points, and the amount of information is calculated and the formation mechanism of the debris flow is analyzed. The state grading diagram of each evaluation factor is made, and the number and proportion of debris flow in each area are counted.

4.1.1. Altitude. The contour map is used as data source to get raster data of 30 m accuracy in the study area. The natural breakpoint grading method in ArcGIS is used to classify and calculate the ratio of debris flow. The debris flow is mainly distributed in the range of 300-800 m. The status classification diagram is shown in Figure 1.

4.1.2. Slope. The contour map is used as data source to get raster data of 30 m accuracy in the study area. From 0 degrees, the number of debris flow points is counted by the classification method of internatural breakpoint classification at 5 degrees for step length. By statistical analysis, the debris flow points in the study area are mainly distributed in the range of 0 -25 degrees. The status classification diagram is shown in Figure 2.

4.1.3. Slope direction. Based on the DEM data of 30 m accuracy, the raster grid is generated by the raster surface tool of ArcGIS spatial analysis. The slope direction can be divided into 10 categories, and the proportion of debris flow under different grading conditions is counted. It can be seen that the debris flow points are mainly distributed in 0-90°.Slope state classification diagram is shown in Figure 3.

4.1.4. Annual precipitation. The debris flow in the study area is the occurrence of debris flow for many years, so the annual average precipitation is chosen as the index factor. According to the atlas of Jilin's land and resources, the annual precipitation map of the study area was plotted by ARCGIS, and the precipitation in the study area was divided into 4 areas: 819-851mm, 851-869mm, 869-984mm and 984-1010mm. The status classification diagram is shown in Figure 4.

4.1.5. River action. The water system of the study area is relatively developed and belongs to the Tumen River Basin. Using the river in the study area as the buffer center, the 0-100m, 100-200m and 200-500m buffer zones are analyzed. The results show that there are 112 debris flow points distributed in the range of the river 500m. Therefore, the occurrence of debris flow is closely related to the role of rivers. The status classification diagram is shown in Figure 5

4.1.6. Fault action. The fault map is made by converting the whole Yanbian fault map to a grid map with ARCGS software. This paper makes the analysis of the three level buffer zones of 0-500m, 500-1000m and 1000-2000m, and reclassifying them. Statistical analysis showed that 84 debris flow points were distributed within 2000m of the fault. Therefore, the occurrence of debris flow is closely related to the distance fault. The status classification diagram is shown in Figure 6.

4.1.7. Stratigraphic lithology. Based on the geological map of the study area, according to the engineering geological properties of the rock and soil, the rock groups in the study area are divided into 3 categories according to the soft and hard degree: hard rock, hard rock and soft rock, and the stratigraphic lithology classification state diagram is shown in Figure 7.

4.1.8. Land use. The main types of land use in the study area are forests, residential areas, orchards and so on. In this paper, we use GIS tools to make statistics on each type of area. Forests spread all over Yanbian, accounting for 70% of the total area of Yanbian. The residential area accounts for about 8% of the area of Yanbian. The total area of the orchard Yanbian area is 7%. As an important factor in the occurrence of debris flow, although the proportion of the whole area of Yanbian is very small, this paper also studied it as a type of land use. In this paper, land use is reclassified by GIS and divided into four categories: residential area, orchard, forest and river. The status classification diagram is shown in Figure 8.

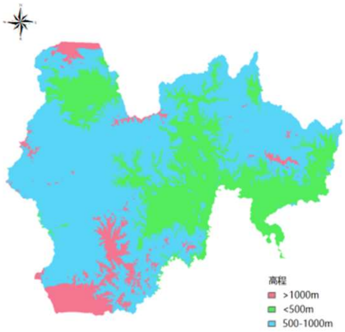

Figure 1. Elevation state Classification diagram

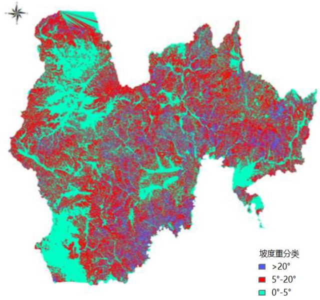

Figure 2. Slope state classification diagram

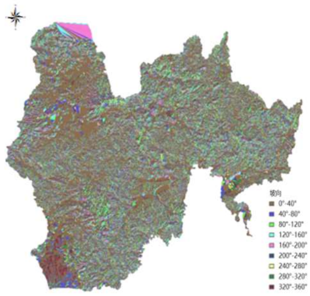

Figure 3. Slope state classification diagram

Figure 4. Annual precipitation state classification diagram

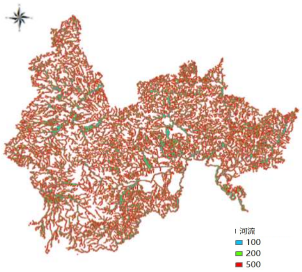

Figure 5. River action state classification diagram

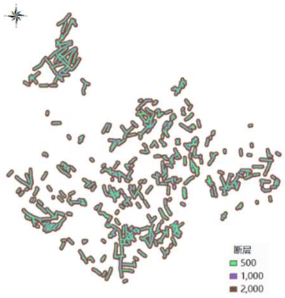

Figure 6. Fault action state classification diagram

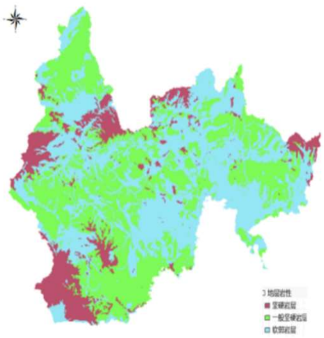

Figure 7. Stratigraphic lithology state classification diagram

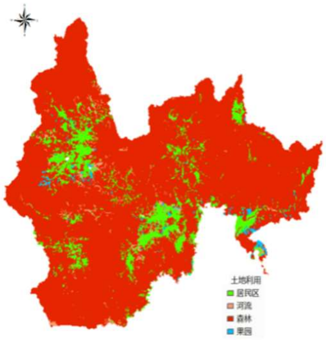

Figure 8. Land use state classification diagram

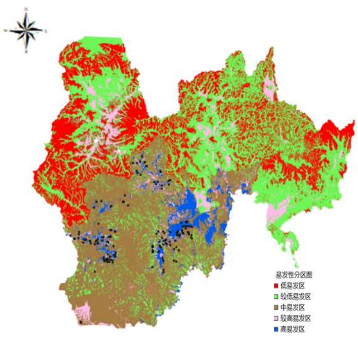

Figure 9. Final easily prone partition map

4.2. Information Calculation and Vnlnerability Assessment

After establishing the evaluation index system, the information quantity of each evaluation index is calculated according to the formula The distribution of debris flow in each category of each factor is obtained by the spatial analysis of each evaluation factor layer and the corresponding debris flow chart in ArcGIS, and the distribution density of the debris flow in each type of each factor is the information amount of each category. The information level under each factor classification is shown in Table 1.

Table 1. Weighted information values of each factor state

index factors	hierarchical state	Debris flow number	information conte
Altitude	1-500	68	0.3638
	500-1000	93	-0.0929
	1000-2800	2	-1.9230
slope	0-5	100	0.3460
	5-20	57	-0.2697
	20-87	6	-1.0762
slope direction	0-90	100	0.1586
	90-180	12	-0.7554
	180-360	51	0.0117
stratigraphic lithology	hard	6	-1.2892
	Generally hard	51	-0.2970
	fragile	106	0.3787
land use	forest	61	-0.8714
	river	8	-0.7455
	residence	94	5.6801
annual precipitation	819-851	1	-3.6730
	851-869	73	0.7671
	869-894	1	-4.1790
	894-1010	88	1.1172
Fault action	0-500	23	0.8079
	500-1000	23	0.7409
	1000-2000	28	0.2670
	>2000	89	-0.3017
River action	0-100	38	0.3117
	100-200	24	0.2764
	200-500	50	0.0696
	>500	51	-0.8908

Under the ArcGIS platform, the amount of information calculated under each hierarchical state is assigned to each hierarchical grid, and the information grid layer of 8 evaluation indexes is obtained. According to the formula (4), the total amount of information of all evaluation units in the whole study area can be obtained by adding the ArcGIS grid calculator and adding 8 information grid layers. The total amount of information of all evaluation units in the region is I. The higher the information value is, the more likely the occurrence of debris flow disasters is.

According to the natural break point method (Natural Break) can be divided into 5 grades, low prone area [-11, -7.4], lower prone area [- 7.4 -3.6], middle prone area [-3.6,0.2], higher prone area [0.2,4.1], high prone area [4.1,7.8], and the most post prone partition map.Then get the final easily prone partition map. Final easily prone partition map is shown in Figure 9.

5 Result Analysis and Accuracy Evaluation

4.3. Susceptibility Analysis

The zoning results of debris flow susceptibility assessment indicate that the high prone area of debris flow in Yanbian Prefecture is mainly located in the central part of Antu county and the central part of Helong city. The structural characteristics of the high prone area are relatively active, and the lithology and quality of formations are poor, which provide abundant solid debris for debris flow. The role of the drainage system also plays an important role in the development of disasters. The closer the drainage line is, the easier the disaster will happen. The high prone areas of debris flow are mainly areas with strong human activities. Human production, life, farmland reclamation and engineering construction have greatly influenced the natural environment, resulting in the loss of soil and water and the reduction of vegetation coverage, which provide favorable conditions for the formation and development of debris flow. 10.4% of the study area is in the high prone area and the high prone area, accounting for 22.8% of the low incidence areas, indicating that most areas are located in the low debris flow prone areas.

4.4. SUSCEPTIBILITY EVALUATION
The number of debris flow, the number of grids, the ratio of debris flow to the grid ratio in each vulnerable area were counted. According to Table 2, 80.9% of the debris flow disaster points are located in high prone area and high prone area. In the process of easy to change from low to high, the number of grid is from large to small, and the density of the disaster points increases, and the ratio of debris flow is increasing in the process of low to high. At the same time, the actual rate of debris flow increases. It is in accordance with the principle of grade division.

5. Conclusion
The vulnerability assessment index system of debris flow in Yanbian Prefecture was established by selecting 8 factors. Based on GIS and information quantity model, the vulnerability of debris flow disaster in Yanbian Prefecture was analyzed and evaluated. According to the evaluation results and actual situation, the evaluation results are good.

The high prone area of debris flow is mainly a region with strong human activity. The land use type is agricultural land and residential area. At the same time, the debris flow disaster is easy to occur in the weak lithology area, and the tectonic action and the function of water system have an important influence on the development of the disaster. The main manifestation is the distance from the structure line and the water system line. The more easy the disaster is.

High debris prone areas in Yanbian Prefecture are mainly located in the central part of Antu County, Helong city and Dunhua city.

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