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Model of Bayes discriminant analysis and its application in evaluating debris flow hazard degree

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ABSTRACT

Based on the methods of evaluating debris flow hazard degree being multiple but difficult to come into being a system, a new Bayes discriminant analysis method to assess debris flow hazard degree is presented. After taking the mainly factors of debris flow hazard degree into consideration, the 10 factors related with topography, geology, hydrology and meteorology and human activities are chosen as the evaluating indexes ; and the influence of dimension of the indexes are eliminated by the method of range. Then, the weights of indexes are determined by preference ratio method. Finally, the data of 20 debris flow projects are taken as the training and testing samples so as to build the model of Bayes discriminant analysis for evaluating the debris flow hazard degree ; and the resubstitution method is used to estimate the ratio of mistake-distinguish. Typical debris flow hazard degree in Yunnan-Guizhou plateau and Miyun county is evaluated by this trained model, and it is showed that the results are consistent with the actual situation and the evaluation results of other methods.

KEYWORDS

Debris flow; Hazard degree; Preference ratio method; Weight; Bayes discriminant analysis.

Debris flow is one of the most common geological disaster phenomenons with a sudden and severe harm in the mountains. Due to its run fast, high frequency, wide distribution and destructive,it has great harm to the security of the people and economic development[1]. In recent years,especially,the rapid development of economy also indirectly caused the human irresistible to the natural disaster such as debris flow. Thus,it should be highly valued that study of the debris flow. If the hazard of debris flow could be accurately evaluated,it would be important guiding significance to the disaster prevention and mitigation. In general, hazard degree is used as the index of debris flow risk assessment,which means the size of the possibility of sufferring from damage within the scope of influence[2]. However, due to the debris flow formed by many factors and there exists a complicated nonlinear relationship, that a debris flow risk assessment, become the emphasis and difficulty in domestic and foreign research, still has not formed a system of debris flow risk assessment standard[3-4]. At present, the debris flow risk evaluation method are many, and also has obtained certain achievement. In general, these methods are mainly divided into subjective judgment and objective analysis[5], such as the projection pursuit method[6], the neural network method[7],efficacy coefficient method[8], combination empowerment method[9] and so on. But there is no one way is universal, and considering the debris flow formation of the regional differences, and each has its own limitations, such as neural network to sample is too strict, efficacy coefficient method of early warning level and rainfall index relationship subject to regional restriction, subjective and objective empowerment ways of combination empowerment theory are too much,causing combination forms are difficult to form a system, etc. In view of this, constantly trying new method for accurate evaluation of debris flow hazard and promoting its formation system evaluation theory is of great significance.

The Bayes discriminant analysis method is a criterion based on the Bayes statistics theory. this method,due to its unique knowledge expression form, rich probability model and incremental learning characteristics based on prior knowledge has penetrated the different areas of the natural science and social science, and achieved some results[10-11]. Based on the above research, this paper,referring to the basic idea of the Bayes discriminant analysis with instances of debris flow risk as the training sample, selecting the 10 major factors influencing the risk of debris flow as the evaluation index, and observing the data to obtain the corresponding criterion, evaluates the risk of new debris flow gully, in order to achieve good results.

THE ANALYSIS OF THE DEBRIS FLOW RISK EVALUATION INDEX

The determination of evaluation index

Risk of debris flow and its formation conditions are inseparable, the study shows that the formation of debris flow is mainly related to geological conditions, topography, geomorphology, hydrology and meteorology and human conditions and other factors. Specific performance is as follows.

Geological conditions. Solid materials are needed very much in the basin,which can be persistently taken to debris flow. For example,landslide、collapse and other bad geological phenomenon,which provide a powerful condition for the accumulation of the solid materials,easily appear in the region of complicated geological texture and intense textonic movement where the rock is broken;

Topography. Steep terrain and large longitudinal slope gully bed not only can concentrate the flow, as well as provides outbreak of debris flow with enough power and energy conditions ;

Hydro meteorology. The occurrence of debris flow is dependent on the water. Water not only can infiltrate saturated loose material, the slope slip increase with the decrease of the frictional resistance, but also can carry out erosion and emptied of the loose material;

Human condition. With the development of economic construction,human transform nature unceasingly, soil ersion is serious, mining slag also indirectly to the formation of debris flow source provides a lot of loose material.

Therefore, considering the above impact conditions, selection of 10 main impact factors to evaluate debris flow risk. Namely,the

Basin area F_1 (km^2) 、the channel length F_2 (km) 、maximum relative elevation differenceF_3 (km) 、valley cutting density F_4 (km/ km^2) 、main ditch bed bend coefficientF_5 、sediment supply length ratioF_6 、 daily maximum rainfallF_7 (mm) 、debris flow scale F_8 (10^4m^3) 、the frequency of occurrence of debris flowF_9 (%) and river basin population density F_{10} (number/ km^2) . After Liu Xilin[2]practice for many years. the 10 factors could be divided into the following four levels: debris flow risk mild dangerous Ⅰ, moderate Ⅱ, highly dangerous Ⅲ and extremely dangerous Ⅳ, the risk level and the relationship between the evaluation index are shown in TABLE 1

TABLE 1 : The relationship between the risk level and the evaluation index

Rank	F_1/km^2	F_2/km	F_3/km	F_4/km·km^{-2}	F_5	F_6	F_7/mm	F_8/10^{4}m^3	F_9/%	F_{10}/numb·km^{-2}
I	0～0.5	0～1	0～0.2	0～5	0～1.1	0～0.1	0～25	0～1	0～10	0～50
II	0.5～10	1～5	0.2～0.5	5～10	1.1～1.25	0.1～0.3	25～50	1～10	10～50	50～150
III	10～35	5～10	0.5～1.0	10～20	1.25～1.4	0.3～0.6	50～100	10～100	50～100	150～250
IV	35～55	10～25	1.0～3.5	20～30	1.4～2.0	0.6～1.0	100～200	100～200	100～1600	250～350

The evaluation index weight calculation

The importance of the influence of different factors on debris flow risk each are not identical, in order to highlight the differences between each influence factor, you first need to eliminate the effects of different dimensions, for each indicator, secondly by certain empowerment method,assigning different weights to different indicators, make evaluation results more reasonable.

The evaluation index non-dimension processing

According to the TABLE 1, the 10 evaluation indexes selected have different dimension,eliminate the impact of the dimension of the evaluation results by range standardization method. Its expression is as follows:

$$x_{ij} = \left(x_{ij}^* - x^*_{j\min}\right) / \left(x^*_{j\max} - x^*_{j\min}\right) \quad (1)$$

Where, x_{ij}^* 、 x_{ij} represent the evaluation index value before and after the non-dimension procession,the first I first j,respectively.

$x^*_{j\max}$、 $x^*_{j\min}$ represent themaximun and minimun evaluation index value before and after the non-dimension procession, the jth,respectively.

Preference ratio method to determine index weight

Preference Ratio method[13-14] is a kind of subjective judgment,to evaluate the relative importance of the evaluation index according to evaluators psychological preferences. The method defines the preference ratio between two indexes, namely relative importance. Under this preference ratio scale, if the marginal contribution rate of an index to the evaluation result is greater than one of another indicator, so the index's importance degree should be a little stronger than the other indicators, the relative importance between indicators and corresponding ratio scale are shown in TABLE 2. Might as well assuming n evaluation indexes and the index of relative importance is$C_1 \geq C_2 \geq \ldots \geq C_n$, a_{pq} (p and q are integer value between 1 ~ n) represent judgment value of evaluators comparingC_p with C_q, it is concluded that the ratio of scale can establish a_{pq} related equations as follows:

$$\begin{cases} a_{11}w_1 + a_{12}w_2 + \cdots + a_{1n}w_n = nw_1 \\ a_{22}w_2 + a_{23}w_3 + \cdots + a_{2n}w_n = (n-1)w_2 \\ \cdots\cdots \\ a_{n-1,n-1}w_{n-1} + a_{n-1,n}w_n = 2w_{n-1} \\ w_1 + w_2 + \cdots + w_n = 1 \end{cases} \quad (2)$$

Where,w_j represents the weights of different evalution.

TABLE 2 : The ratio scale values

Compar C_p and C_q	v large	large	larger	s larger	equal	between	Compar C_p and C_q
Ratio scale values	5	4	3	2	1	namely 4.5、3.5、2.5 and1.5	The reciprocal values

BAYES DISCRIMINANT MODEL OF DEBRIS FLOW RISK

The basic idea of bayes discriminant model

The Bayes discriminant method is derived from a discriminatory analysis of bayesian statistical thoughts,the basic idea[15] is : firstly,assuming the object of study has a certain understanding, and this understanding to prior probability to describe, and then make a sample, use sample to revise the existing knowledge, get a posteriori probability distribution. For an classification-unknown sample, only need to compare the size of the a posteriori probability, pending approval sample will be sentenced from the largest posterior probability of overall. The following mainly introduces the basic knowledge of the Bayes discriminant analysis[16] and Bayes discriminant model of debris flow risk.

Bayes discriminant function

Given K n elements in general,respectly,G_1、G_2、…、G_k（k≥2）. For any of a general G_a（a=1，2，…，k），mathematical expectation is$\boldsymbol{\mu}_a$,Covariance matrix is $\boldsymbol{\Sigma}_a$,The markov distance of the sample $\boldsymbol{X} = (x_1, x_2, \cdots, x_n)^{\mathrm{T}}$ to general G_a *is*

$$d(\boldsymbol{X},\boldsymbol{G}_a) = \sqrt{(\boldsymbol{X}-\boldsymbol{\mu}_a)^{\mathrm{T}}\boldsymbol{\Sigma}_a^{-1}(\boldsymbol{X}-\boldsymbol{\mu}_a)} \tag{3}$$

From the each n elements in general take two generals:G_p、G_q, mathematical expectation is respectly$\boldsymbol{\mu}_p$、$\boldsymbol{\mu}_q$, Difference of squares of the markov distance of the sample $\boldsymbol{X} = (x_1, x_2, \cdots, x_n)^{\mathrm{T}}$ to general G_p、G_q :

$$d^2(\boldsymbol{X},\boldsymbol{G}_q) - d^2(\boldsymbol{X},\boldsymbol{G}_p) = -2[W_q(\boldsymbol{X}) - W_p(\boldsymbol{X})] \tag{4}$$

Where, $W_q(\boldsymbol{X})$、$W_p(\boldsymbol{X})$ are all discriminant function, and represented respectively $W_p(\boldsymbol{X}) = (\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu}_p)^{\mathrm{T}}\boldsymbol{X} - 0.5\boldsymbol{\mu}_p^{\mathrm{T}}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu}_p$ 、 $W_p(\boldsymbol{X}) = (\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu}_p)^{\mathrm{T}}\boldsymbol{X} - 0.5\boldsymbol{\mu}_p^{\mathrm{T}}\boldsymbol{\Sigma}^{-1}\boldsymbol{\mu}_p$ In practical applications, the mathematical expectation $\boldsymbol{\mu}$ and covariance matrix $\boldsymbol{\Sigma}$ are unknown, but adopting the training sample mean and variance as the estimate instead.

Bayesian criteria

For the general G_a, the probability density of the sample X is as follows :

$$f_a(\boldsymbol{X}) = (2\pi)^{-n/2}|\boldsymbol{\Sigma}_a|^{-1/2}\exp[-0.5d_a^2(\boldsymbol{X},\boldsymbol{G}_q)] \tag{5}$$

According to the Bayes statistics theory,the posterior probability of X belonging to G_a is

$$P(\boldsymbol{G}_a|\boldsymbol{X}) = q_a f_a(\boldsymbol{X}) \Big/ \sum_{a=1}^{k} q_a f_a(\boldsymbol{X}) \tag{6}$$

Where, q_a represents the former probabilistic of X belonging to G_a,which can be estimated by the propotion of general Ga in all the general in training samples. namely, $q_a = n_a/(n_1+n_2+\cdots+n_k)$,($n_a$=the number of sample in the general G_a),and also $\sum_{a=1}^{k} q_a = 1$,In addition, the generalized square distance of X to the general G_a:

$$D_a^2(\boldsymbol{X}) = d_a^2(\boldsymbol{X}) + g_a + h_a \tag{7}$$

Where,

$$g_a = \begin{cases} \ln|\boldsymbol{\Sigma}_a|, \text{若}\boldsymbol{\Sigma}_1, \boldsymbol{\Sigma}_2, \cdots, \boldsymbol{\Sigma}_k\text{不全相等} \\ 0, \text{若}\boldsymbol{\Sigma}_1 = \boldsymbol{\Sigma}_2 = \cdots = \boldsymbol{\Sigma}_k = \boldsymbol{\Sigma} \end{cases} \tag{8}$$

$$h_a = \begin{cases} -2\ln q_a, \text{若}q_1, q_2, \cdots, q_k\text{不全相等} \\ 0, \text{若}q_1 = q_2 = \cdots = q_k = 1/k \end{cases} \tag{9}$$

The posterior probability of X belonging to G_a is

$$P(\boldsymbol{G}_a|\boldsymbol{X}) = \frac{\exp[-0.5D_a^2(\boldsymbol{X})]}{\sum_{a=1}^{k}\exp[-0.5D_a^2(\boldsymbol{X})]} \tag{10}$$

By the basic thoughts of the Bayes discriminant analysis, building the following criterion:

$$若P(\boldsymbol{G}_i|\boldsymbol{X}) = \max_{1\le a\le k} P(\boldsymbol{G}_a|\boldsymbol{X}) \xrightarrow{由(4)\sim(10)} W_i(\boldsymbol{X}) = \max_{1\le a\le k} W_a(\boldsymbol{X}),\ 则\boldsymbol{X} \in \boldsymbol{G}_i \tag{11}$$

The bayes discriminant model of debris flow risk assessment

According to the domestic several flow gully risk evaluation[1,6,9,17]. Select 20 engineering examples which the debris flow risk have been identified as a learning training sample(TABLE 3). Taking the above 10 impact factors indexes to evaluate debris flow risk as the input unit,and then carring out the standardization processing to generate the training sample set,With the four different levels of debris flow risk finally (general) of the output unit,to establish the Bayes discriminant model of debris flow risk assessment.(Figure 1)

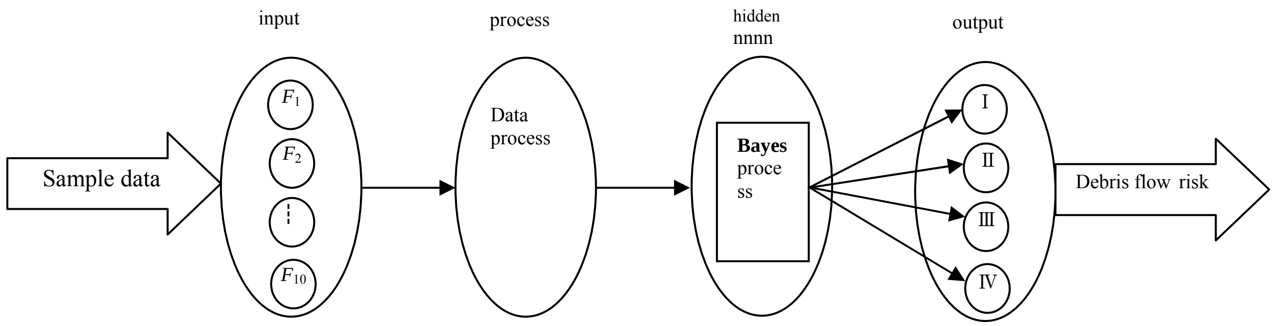

Figure 1 : He Bayes discriminant model of debris flow risk assessment

From Figure 1, the study on the training samples in TABLE 3: firstly, by using formula (2) and TABLE 2 in which sample data areprovided, the weight of each evaluation index, can be given respectively :0.0977、0.1239、0.1322、0.1156、0.1262、0.0753、0.1799、0.0804、0.0459、0.0230 ; secondly,eliminate the impact of the dimension of the evaluation results by range standardization method and make evaluation results more reasonable. Finally, using the formula (3) and (4), through the Bayes discriminant analysis processing, the Bayes discriminant function of debris flow risk evaluation is established. discriminant functions respectly are :

$$W_1(X) = -1924x_1 + 4261x_2 + 3154x_3 + 2266x_4 + 4573x_5 - 1651x_6 + 2247x_7 - 2782x_8 + 11169x_9 + 13535x_{10} - 423.415$$

$$W_2(X) = -1042x_1 + 2740x_2 + 4886x_3 + 2809x_4 + 4000x_5 - 2349x_6 + 3021x_7 - 5146x_8 + 17765x_9 + 21081x_{10} - 530.297$$

$$W_3(X) = -1351x_1 + 3315x_2 + 3989x_3 + 2573x_4 + 4053x_5 - 1881x_6 + 2587x_7 - 4273x_8 + 15039x_9 + 18692x_{10} - 448.318$$

$$W_4(X) = -3976x_1 + 9105x_2 + 4593x_3 + 4121x_4 + 6352x_5 - 2545x_6 + 3039x_7 - 3968x_8 + 18941x_9 + 22521x_{10} - 1051$$

Where, $W_1(X)$、$W_2(X)$、$W_3(X)$、$W_4(X)$ respectively represent mild Ⅰ risk, moderate risk Ⅱ, severe risk Ⅲ and extremely dangerous Ⅳ linear discriminant function of the sample, the x1 ~ x10 respectively represent evaluation data after the normalized and weighted processing.

The Bayes discriminant model test of debris flow risk assessment

To test the rationality of the discriminant model,discriminating the 20 selected sample one by one by the test model established, the results are listed in the TABLE 4. And then,calculating the misjudgment rate of the model through the formula (12) below. according to the results in the TABLE 4. The test model falsely discriminate the debris flow risk of Longtanggou as the Severe danger,the model misjudgment rate of 0.05,reaching the standard of the Bayes discriminant, discriminant results and actual situation are good, high precision, having verified the change training model is stable and efficient.

TABLE 3 : Statistics of some domestic debris flow risk

Rank	Name	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	risk
1	Zhugong	6.50	4.98	1.34	6.24	1.15	0.50	112.50	4.00	23.00	50.00	III
2	Shuilvq	37.10	10.51	1.74	6.72	1.12	0.46	114.50	19.30	102.56	10.00	III
3	Lufangp	1.23	2.11	1.04	19.30	1.09	0.51	115.40	6.45	152.29	0.00	III
4	Erpingz	0.83	1.55	0.41	21.88	1.29	0.23	121.20	7.54	186.16	0.00	III
5	Baitanx	3.10	3.08	1.26	5.51	1.19	0.22	110.00	7.04	54.00	40.00	III
6	Aibag	5.84	5.08	1.48	8.79	1.19	0.62	111.50	8.37	72.00	68.00	III
7	Xiaosg	3.60	3.92	1.34	9.40	1.17	0.15	161.50	4.40	39.34	0.00	II
8	Kuasq	1.18	2.78	1.29	15.50	1.13	0.12	118.50	5.74	114.88	0.00	II
9	Yanshe	4.87	4.36	1.91	9.00	1.35	0.30	112.50	3.33	18.57	0.00	II
10	Longtang	2.18	2.54	1.03	13.70	1.18	0.50	151.50	5.36	91.15	0.00	II
11	Hujiag	8.62	5.16	1.53	6.34	1.26	0.44	118.20	14.10	333.00	10.00	II
12	Huapingz	4.75	2.68	1.02	14.36	1.13	0.09	112.90	6.84	97.31	20.00	II
13	Xiguadi	2.09	2.87	0.80	13.64	1.12	0.07	171.10	4.31	80.72	2.00	II
14	Fujiag	8.62	5.16	1.53	6.34	1.26	0.44	110.00	12.90	66.30	10.00	I
15	Zhuzhah	152.60	26.30	1.30	4.32	1.70	0.08	111.50	31.20	10.50	4.00	I
16	Fujiagou	8.62	5.16	1.53	6.34	1.26	0.44	111.50	12.90	66.30	10.00	I
17	Heizhe	51.70	13.90	1.31	5.12	1.15	0.12	111.50	15.03	2.30	9.00	I
18	\	47.10	12.00	2.19	23.80	1.45	0.80	102.00	195.10	1500.0	260.00	IV
19	\	53.10	18.35	2.92	21.20	1.28	0.62	97.00	105.00	450.00	210.00	IV
20	\	18.05	11.80	1.66	22.80	1.39	0.72	100.40	82.00	1200.0	0.00	IV

$$\eta = (n_1^* + n_2^* + \cdots + n_k^*)/(n_1 + n_2 + \cdots + n_k) \quad (12)$$

Where, η =the disjudgment rate, n_a^* =the number of sample belonging to G_a which are fasely discriminated to belonging to other general.

TABLE 4 : The results of the Bayes discriminant model test

Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Bayes Discrim	III	III	III	III	III	III	II	II	II	III	II	II	II	I	I	I	I	IV	IV	IV
Actual risk	III	III	III	III	III	III	II	II	II	II	II	II	II	I	I	I	I	IV	IV	IV

ENGINEERING APPLICATION

Engineering example 1

In one part of the yunnan-guizhou plateau,altitude of about 1~2km,fracture、uplift and so on tectonic activities are very development,types of the debris flow source is more,mainly including :Horse shop river ancient collapse body and a dragon street group not good consolidation of mudstone, phyllite and gneiss collapse and landslide body, etc. Rickle in the debris flow region is more and more with the slope sediments and diluvium appear alternately, stratification is obvious. Survey found that the region's soil erosion, and vegetation coverage rate is low, increased the instability of loose deposit. By the method of aerial photo interpretation and field investigation, determined the region each evaluation index of the following three mud-rock flow,as shown in TABLE 5[17].

TABLE 5 : The research object index data

Rank	Address	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
1	Jianshan	16.78	6.02	1.06	3.60	1.23	0.44	161.20	6.09	0.00	238.00
2	Xiaoshui	3.60	3.92	1.34	9.40	1.17	0.15	161.50	4.40	39.34	0.00
3	Yanshui	4.87	4.36	1.91	9.00	1.35	0.30	112.50	3.33	18.57	0.00

By Bayes discriminant analysis model established, the discriminant analysis of risk of 3 debris flow gullies in TABLE 5, the results are shown in TABLE 6, the results accord with the situation of actual survey, also is consistent with the mutation model discrimination results, this indicates that the method is reasonable. But, by contrast, the Bayes discriminant analysis depend on the sample information and consider the sample on the basis of the prior probability to quantify the possibility of the results,more objective, and the future can continually improve and reuse sample data according to particular case, which makes the evaluation more scientific.

TABLE 6 : Bayes discriminant model test results

Rank	Name	Bayes discriminant model				Results	Mutation mode	Actual rank
		$W_1(X)$	$W_2(X)$	$W_3(X)$	$W_4(X)$			
1	Jianshan	624.4	723.5	698.9	519.7	II	II	II
2	Xiaoshui	534.2	570.1	554.2	367.1	II	II	II
3	Yanshui	534.0	554.9	546.4	372.8	II	II	II

Engineering example 2

Taking the 3 debris flow ditches within the teeritory of miyun county in the literature[3] as an example The basic situation is as follows:loose deposits of debris flow is more, mainly composed of the ancient collapse, and the collapse of the body ishalf diagenetic state, also,weathering resistance is poor,and the natrue of disruption is strong, under the effect of rain landslide and collapse are common. In addition, on both sides of the debris flow valleys, the bedrock is given priority to with limestone, modetate weathering, joint fissure development very much, density is bigger, easily to collapse. Field investigation found that both sides of the slope was very steep, the bayonet and existes in development, in the case of heavy rain easily mudslides happened, debris flow concrete index data as shown in TABLE 7.

TABLE 7 : All the index data

Rank	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}
1	2.96	3.25	1.12	5.12	1.15	0.36	245	3.2	25	80
2	0.95	1.65	0.76	9.95	1.28	0.62	245	3.7	45	110
3	3.25	4.25	1.27	6.35	1.26	0.45	245	4	36	80

According to the established the Bayes discriminant function, discriminant analysis of the samples in TABLE 7, the results are shown in TABLE 8,it noted that the moderate to severe dangerous debris flow will happen. Finally,contrasting the evaluation results with the previous debris flow risk evaluation results of miyun county region [18], such as in the document 18 the analytic hierarchy process (ahp) is adopted to Beijing overall flow gullies risk zoning analyses, the analysis results show that miyun county belongs to the moderate to severe danger zone, in accordance with the results,and the model presented in this paper is the rational At the same time, considering of the influence factors is more comprehensive, more objective, and fully quantify the level of their risk of debris flow gully, the practical meaning more clearly.

TABLE 8 : Bayes discriminant model test results

Rank	Bayes discriminant model				Results
	$W_1(X)$	$W_2(X)$	$W_3(X)$	$W_4(X)$	
1	666.5	771.1	727.1	532.3	□
2	675.1	773.9	738.2	543.2	□
3	737.1	838.4	794.4	650.8	□

CONCLUSION

Due to many of debris flow influence factors and there exists a complicated nonlinear relationship between various factors,debris flow risk assessment has become the emphasis and difficulty in debris flow disaster research field. However, the current theoretical methods to form system is not easy, therefore, to find a new method for debris flow risk assessment is very necessary, the Bayes discriminant model of debris flow risk evaluation based on this is proposed in this paper.

Starting from the conditions of debris flow formation, comprehensive selection of 10 factors related to the debris flow risk,namely topography, geology, hydrology and meteorology, and human impact and so on. as evaluation indexes, and data after dimensionless treatment and then preference ratio method is used to assign different weights to the 10 factors, makes a more scientific and reasonable evaluation index data.

Based on the Bayes discriminant analysis theory, after learning the training sample. The Bayes discriminant of debris flow risk assessment model is established, and through the back generation estimation method to test the accuracy of the model. Inspection results and example show that the model can better evaluate debris flow risk, and the evaluation result accords with the actual,and also has a certain practicality.

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