

Study on the review of the risk assessment of debris flow

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Abstract. The research situation on risk assessment of debris flow was reviewed in this paper. At first, the distribution of debris flow in China was studied. And then the evaluation methods were introduced, including the Gray Forecast Evaluation Method the Artificial Neural Network Evaluation Method, the Information Entropy Theory Evaluation Method, Fuzzy Comprehensive Evaluation Method, the RS and GIS Evaluation Method and the application of Analytic Hierarchy Process in risk assessment of debris flow. Finally, the difficulties in risk assessment of debris flow has been discussed. From the study of this paper, there is a more comprehensive understanding on the risk assessment method of debris flow, which will be used as a reference in the study of the risk assessment method of debris flow in the future.

1. Introduction

Debris flow is a kind of common sudden occurred in a mountainous area of geological disasters, it is in the hydraulic condition, landform, geological condition and human condition under the joint action of a cross between collapse, landslide, collapse and other large pieces of material movement and carrying the fluid-structure interaction between the flow phenomenon of flow, solid particulate matter is a very high concentration of solid and liquid two phase mixture of nonlinear large deformation of the fluid[1]. It has extremely strong destructive, not only pose great threat to people's lives and property, but also cause serious damage to the local ecological environment. Fig.1 shows pictures of houses and roads that were destroyed in the debris flow in 2010, in Sichuan Province.



(a) Destroyed houses (Qingping Town)



(b) Destroyed highway (Yingxiu Town)

Fig.1 Some damages caused by debris flow

There are lots of mountainous in China, so debris flow is one of the most frequent disaster in China. It occurs more than 1000 per year, more than 1000 people are injured and dead, the affected population is more than 900000, and direct economic loss is about 20 to 60 billion yuan per year. Fig. 2 shows the quarterly distribution of debris flow in China from 2010 to 2016, and it can be seen from



the graph that summer is the peak period of debris flow, which indicates that the occurrence of debris flow is relatively large.

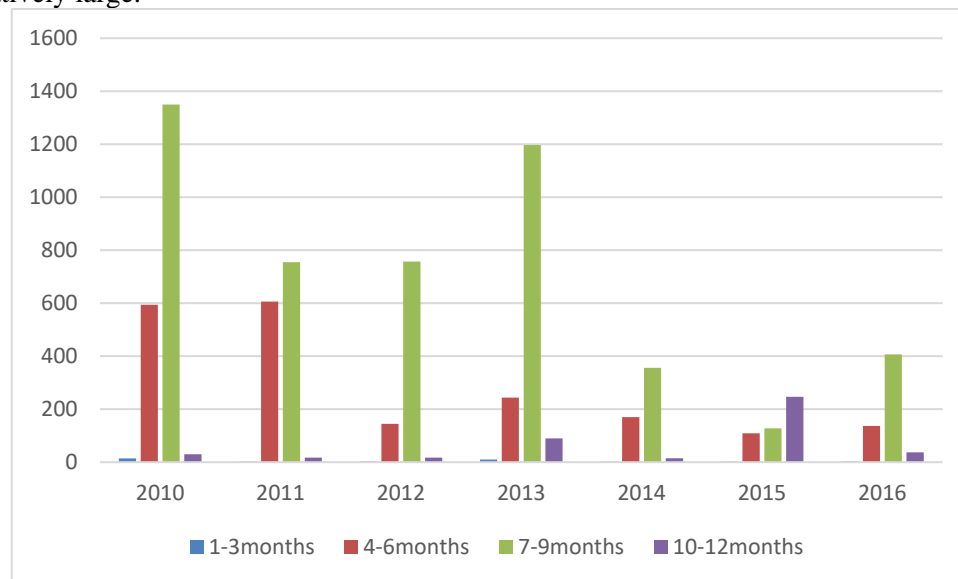


Fig.2 The quarterly distribution of debris flow in China (2010 -2016)

2. Study on the risk assessment of debris flow

Risk assessment, also known as the safety evaluation, it is to point to in risk identification and estimation, on the basis of considering the probability of occurrence of a risk, loss rate and other factors, it is concluded that the possibility of system risk and its degree.

In 1991 and 1992, the United Nations department of humanitarian affairs officially released the definition of the risk of natural disasters[2-3]:“Risk is the expected loss value of people's life and property and economic activity caused by a natural disaster in a given region and given time.”The United Nations department of humanitarian affairs presents an expression for the risk of natural disasters is as follows[4]:

$$\text{Risk} = \text{Risk degree} \times \text{Vulnerability}$$

2.1 Risk degree

The risk reflects the natural property of the disaster, which is the function of the disaster scale and frequency (probability).

The risk degree of debris flow disaster mainly depends on the dynamic conditions of the debris flow disaster - mainly including geological conditions (geotechnical properties and structure, active structure and so on), geomorphic conditions (geomorphologic type, degree of cutting, etc), meteorological conditions (precipitation, rainfall intensity, etc), artificial geodynamic activities (engineering construction, mining, planting, grazing, etc) [5].

According to the research scope, it can be divided into point evaluation (single gully debris flow risk assessment) and surface evaluation (regional debris flow risk assessment). Single gully debris flow risk assessment refers to a flow gully or close, a unified power activities and destruction of objects are some of the debris flow gully or group, it is the foundation of other evaluation, evaluation is the feature of the area is small, hazard-affected bodies and clarity of hazard-affected bodies, evaluation of high precision, using the index, model, and it is concluded that the high degree of quantitative evaluation results[6]. The area is generally divided into three types: grid region, natural region and administrative region. Italian landslide expert Dr. Carrara believes that the grid region and natural region have advantages and disadvantages as evaluation units[7], and the administrative region is the evaluation unit, which can be regarded as the combination of the grid regional unit and the natural

regional unit in a certain degree[8].It can provide scientific basis and technical support for disaster prevention and reduction planning and disaster relief work.

2.2 vulnerability

The vulnerability reflects the social attribute of the disaster, which is the function of the population, property, economy and environment of the disaster. In 1991, the international decade for disaster prevention, reduction, mitigation and environmental protection outlined in the international decade for natural disaster reduction was presented. As an important part of disaster assessment, natural disaster vulnerability assessment has attracted the attention of all scholars in the disaster field, so that the vulnerability of natural disasters has been developed. The United Nations Disaster Relief Office and UNESCO(United Nations Educational, Scientific and Cultural Organization) put forward a standard definition of vulnerability to natural disasters in 1980:Under the action of the natural phenomenon of specific strength, the degree of loss of the disaster body is from 0(no damage) to 1(complete damage)[9]. Prof. Panizza, a prominent Italian environmental geomorphologist, defined vulnerability in 1996,“Vulnerability is a complex of all people and things that may be directly or indirectly sensitive to a region of material loss in the context of human intervention”[10]. It clearly defines vulnerability as a combination of people and things, including all material losses caused by natural disasters. On the basis of the definition of vulnerability to natural disasters proposed by the United Nations, Chinese scholar Liu Xilin defined vulnerability as “the potential maximum loss of any person, treasure or property in a given region and within a given period of time due to the debris flow disaster” with the understanding of Prof. Panizza[11].

3. Debris flow risk assessment method

Currently there are some method that are used in the risk assessment of debris flow, which including Grey Prediction Method, Artificial Neural Network, Information Entropy Theory, Fuzzy Comprehensive Evaluation Method, the RS and GIS Evaluation Method and Analytic Hierarchy Process.

3.1 Grey Prediction Method

The whole information of a system is known as the white system, the whole information is unknown as the black box system, and the system in which there both has some known information and some unknown information is called grey system. The grey system is between the white system and the black system, and the relationship between each factor is uncertain. In 1987, the concept of “grey system” was firstly proposed by Deng Julong, and it was widely used in the risk prediction of debris flow.

On the basis of determining the main risk factors, Liu Xilin et al.[12](1995) analyzed and calculated the correlation between the 14 candidate factors and the two, and finally determined the secondary factors of the risk assessment of debris flow. Using the grey relational analysis method, Zhang Chunshan[13](1996) quantitatively analyzes the risk of debris flow in Beijing, and establishes the mathematical model of the risk assessment of regional debris flow. Zou Xiang[14](2003) established the risk gray evaluation model of debris flow by evaluating the activity of typical debris flow gully in Yunnan province and tested it. Song Xueda et al.[15](2004) used the method of grey correlation analysis to obtain the quantitative index of the landslide disaster and calculate the weight of each index. Yu Xiuzhi[16](2004) put the various influence factors of debris flow and debris flow scale, the development situation of close degree to do quantitative analysis, according to the weights of each factor were weighted for each factor, the article to the Beijing valleys has carried on the risk evaluation. Combined with the characteristics and harm of debris flow on highway, Yang Sanqiang[17](2008) adopts the grey system analysis method to establish the evaluation system of debris flow hazard in Tianshan highway. Based on rough set theory and grey theory, Luo Guanzhi[18](2008) proposed a method of comprehensive determination, combined with fuzzy mathematics, and evaluated the risk of debris flow and gully in the yi-lushan expressway in

Sichuan.Wei Binbin[19](2013) used the grey correlation method to analyze 72 debris flows in Beichuan county about the scale of debris flow, the basin area, the length of the main ditch, the relative elevation of the basin, the cutting density of the basin, the ratio of the unsteady groove bed and the average annual rainfall and the earthquake intensity of 8 factors. On this basis, the risk assessment model of debris flow is established and the risk assessment is further carried out.

3.2 Artificial Neural Network

Artificial Neural Network is a nonlinear and adaptive information processing system composed of a large number of processing units. Its advantage is that it can connect a large number of neurons into a complex network system, and solve some problems that are difficult to solve with traditional methods by simulating human's thought patterns. A typical neural network structure diagram is shown in Fig.3.

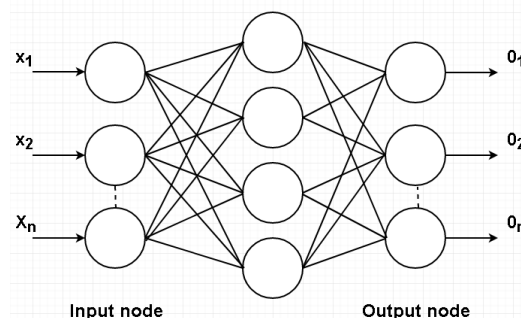


Fig.3 neural network structure diagram

Li Xinpo[20](2005) uses the neural network calculation method, according to the rainfall data and topography data of 31 years in Yunnan province, with administrative districts as evaluation unit, for Yunnan province debris flow risk assessment, the results comprehensive evaluation result is consistent with Tang Chuan[21](1997).Wang Mingwu[22](2000) discusses the neural network model for debris flow risk zoning, expounds its basic principle, the comprehensive indexes of debris flow development, distribution and evolution characteristics to establish artificial neural network model of debris flow risk hierarchy. Wang Xiaopeng[23](2006) combined with GIS technology, the use of artificial neural network of regional debris flow of Xiuyan county disaster assessment, think to river basin as evaluation unit can fully embody the space characteristics and physical mechanism of debris flow disaster. Li Yangyang[24](2008) by applying neural network model of debris flow risk assessment evaluation results compared with existing debris flow risk assessment results confirmed the validity of neural network in the field of risk evaluation. Li Fabin[25](2003) established a genetic neural network model for the activity of debris flow and used the model to analyze the activity of debris flow along the highway along the highway. He trained the network with 25 of them, and then put the data of the remaining five debris flows into the model to calculate their activity. The calculation results are consistent with the actual observation, and the model is feasible. Cao Lulai, Xu Linrong[26](2014) put the t-s fuzzy system theory and artificial neural network, the combination of using the theory of fuzzy membership degree of fuzziness has a strong recognition accuracy, the debris flow hazard index membership degree as the activation function of the neural network input.They using normal distribution method is used to generate training data, using BP neural network of error back propagation of t-s fuzzy systems for training the parameters of the membership functions and so on, so as to establish a fuzzy neural network model of debris flow risk assessment.

3.3 Information Entropy Theory

Entropy is a measure of the stable state of the system. The greater the entropy of a system, the worse the stability of the system, and the more stable it is. The concept of entropy was first established by R.J. Clausius in the mid-19th century. In 1870, Boltzmann gave a statistical explanation of entropy and established the formula.

Information entropy is also known as negative entropy, which is used to represent the average amount of information sent by an information source. In 1948, C.E. Shannon [27] first proposed the concept of information entropy. Information entropy is used to determine the probability of the occurrence of debris flow and the risk assessment of debris flow by using probability and logical method. Ai Nanshan [28,29] (1987, 1988) puts forward the basin area - elevation curve and its integral to judge the activity of gully debris flow, and applies geomorphology method to the risk assessment of debris flow. Yue Tianxiang [30] (1989) uses the super entropy to evaluate the stability of the debris flow basin system and evaluates the risk of debris flow in the basin. Jiang Zhongxin [31] (1992) put forward by valleys profile expression of entropy mathematical morphology index, through the evolution characteristics of debris flow gully system to evaluate the stability of river system, and put forward the our country southwest rainstorm debris flow gully simple criterion. Liu Jinpeng [32] (2015) used entropy method to assign weights to 10 indexes involved in the risk assessment of debris flow, avoiding the influence of subjective factors. And he applied the improved method - maximum closeness method to solve the multi - factor limit problem of debris flow hazard evaluation. Gao Libing [33] (2017) put the Bailong river basin as study area, on the basis of the collected data and field survey, selection of landform factors and geological factors as the debris flow risk assessment factors, and using the grid unit as the evaluation unit, the study area power environmental factors are analyzed.

3.4 Fuzzy Comprehensive Evaluation Method

Fuzzy comprehensive evaluation method is a systematic analysis method to analyze and evaluate the "fuzziness". It is a kind of analytical evaluation method based on the combination of qualitative and quantitative, accurate and imprecise. Because of this method in dealing with all kinds of difficult to the problems of complex systems is described by using mathematical method of the unique superiority, has in many fields in recent years has been very widely used.

Kuang Lehong [34] (2006) put the method of fuzzy mathematics and extension in the combination of the matter-element theory, extension set theory and dependent function on the basis of the use of regional debris flow risk classification and regionalization index membership degree make its dimensionless constructs the classic and joint domain matter-element and debris flow risk zoning of fuzzy matter-element model is established. Liu Jialong [35] (2001) degree of debris flow in Guizhou province Bijie prefecture as an example to establish disaster evaluation standards and the membership function, based on the fuzzy comprehensive evaluation method of fuzzy pattern recognition theory, the authors made an evaluation of the degree of debris flow disaster. Chen Jie [36] (2003) used the fuzzy relation theory to establish the evaluation method for the activity of glacier debris flow and the activity evaluation of debris flow in the glacier debris flow in Tibet highway. Hou Langong [37] (2004) summarized the methods of the risk assessment of debris flow in the past and introduced the application of fuzzy mathematics, grey theory and technology in the risk assessment of debris flow. Liu Zhangjun [38] (2007) was founded by the method of fuzzy probability of eight typical debris flow gully debris flow risk assessment model of risk is evaluated, the results show that the fuzzy probability method to reduce the debris flow influence factors of uncertainty has a good effect.

3.5 RS and GIS evaluation method.

The risk assessment of debris flow is a comprehensive process involving multiple factors, such as topography, geomorphology, meteorology, vegetation, soil, population, housing and other data. Remote sensing (RS) and geographic information system (GIS) technology are needed for the acquisition, analysis and processing of these spatial data. RS and GIS technology were applied in the study of debris flow hazard evaluation in the late 1990s. Because of the RS and GIS in spatial data extraction, data storage, data analysis, data management has outstanding advantages, can greatly improve the efficiency of study, as a result, the technology is currently one of the indispensable in the study of debris flow risk assessment methods.

In the 21st century, the application of GIS to the risk of debris flow is more mature. Yan Mancun [39] (2001) and Tang Chuan [40] (2002) used GIS as a tool to divide the risk of debris flow in

the area they studied and obtained satisfactory results. In 2008, Bai Liping et al. [41] applied analytic hierarchy process to study the regionalization of risk of debris flow in Beijing. In 2012, Chen Ning [42] used Wenchuan county Yingxiu - tigers of the upper reaches of Minjiang river mouth area as the experimental area, he USES the 3 s technology, source and high precision for multi-scale DEM and remote sensing image as the study area landscape watershed information entropy calculation and data source of geological hazards such as information extraction, combined with geology, geography, hydrology, meteorology, etc. By geological disasters in the study area information of remote sensing digital image processing and interpretation and field investigation, find out the characters and features of geological disasters in the study area and spatial distribution characteristics, and on this basis, adopt various methods to sudden potential debris flow risk zoning and evaluation in the study area. In 2013, Sun Xiufei [43] combine GIS with AHP, the debris flow risk assessment in the area, through the embodiment of the spatial analysis ability, play to Analytic Hierarchy Process (AHP) and the advantage of multi-factor summary analysis and evaluation, effective evaluation factors in the process of quantification, and to discriminate the subjective factors and objective factors of influence weight combination of good. In 2015, Li Guo [44] use of 3d GIS auxiliary research areas nine relatively intact mud-rock flow parameters of information extraction, and then through the multivariate nonlinear regression analysis in the study area are obtained range of debris flow risk prediction mathematical model. GIS technology was applied to debris flow risk assessment, can make full use of computer processing of huge data statistical analysis function, will each impact factor data stack space, by GIS software system analysis, risk zoning map, can be effective at the same time, enhance the efficiency of the evaluation of the results of the analysis is more reliable.

4. Difficulties in risk assessment of debris flow

From the study, it can be found that there are some difficulties in the risk assessment of debris flow:

4.1 The weight coefficient of debris flow risk assessment is difficult.

The risk assessment of debris flow in the region varies with the ground and the evaluation content is complex. Therefore, it is difficult to determine the unified evaluation criterion in evaluation, there is no uniform weight coefficient, and the determination method of weight coefficient is not unified.

4.2 Probability calculation is difficult.

At present, a lot of landslides occur probability will be subject to rainstorm frequency, but some scholars research shows that the landslides have a great relationship with the antecedent precipitation, temporarily not mature probability calculation method, to determine the probability of occurrence is not accurate.

4.3 Vulnerability assessment is difficult.

The study on vulnerability is not yet unified, and some scholars believe that vulnerability is the inherent property of the natural disaster body, between 0 and 1. Some scholars also believe that vulnerability is related to external factors, and that the intensity of debris flow is simple. The assessment is different, the vulnerability is different, and the risk assessment results are different.

5. Conclusion

5.1 According to China's 2010-2016 debris flow occurrence data can be seen that the average mudslide 1063 times a year, and focused on the July - September, about 707 times, accounted for 67%, shows that there is a close relationship between landslides and rainfall in China.

5.2 Can be seen from the debris flow risk assessment, the present study focuses on a detailed analysis and use a variety of evaluation methods for debris flow risk degree, thereby determining debris flow risk degree.

5.3 It can be seen from the vulnerability assessment of debris flow that vulnerability assessment is a comprehensive analysis of the socio-economic level and disaster capacity of the affected areas, which plays an important role in disaster prevention and disaster prevention. At present, it mainly focuses on studying the relationship between the vulnerability of specific types and the intensity of debris flow, and improving the quantitative level of the method of debris flow vulnerability.

5.4 It is difficult to determine the weight coefficient and the vulnerability assessment coefficient of the current risk assessment of rock flow, which still needs to be further solved.

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