Characteristics analysis of regional geological hazards based on spatial distribution of potential hazards

Jing Wang1*, Qionghua Zuo1, Qinhui Huang1, Xi Ying1

1 Yunnan Land and Resources Vocational College, Yangzonghai Scenic Area, Kunming, Yunnan Province, P. R. of China
E-mail: 201310119@ynptxy.edu.cn

Abstract: The regional disaster scenario can be described by the disaster consequence and its evolution trend: the state of the disaster bearing body directly reflects the disaster consequence, and the relationship between the disaster bearing bodies leads to the complex and diverse evolution trend of the disaster consequence. Therefore, taking the disaster bearing body and its association as the core, a network model reflecting the characteristics of the disaster affected area is constructed to describe the regional disaster scenario. Based on the spatial distribution of potential hazards, the characteristics analysis method of regional geological hazards is proposed. This paper analyzes the regional elements of scenario architecture from a systematic point of view. Based on the evolution attribute of disaster bearing bodies, the influence range model of disaster bearing bodies and the influence topological association between them are defined, and the generation method of association network model of regional disaster bearing bodies is proposed. Using this method to construct disaster scenarios reflecting the characteristics of the affected area in advance is conducive to the assessment of the risk of regional disaster loss in advance.

1. Introduction
Economic development is a double-edged sword. On the one hand, it can improve human living standards and meet the growing needs of human beings; on the other hand, it may lead to environmental problems and feed back to human beings\(^1\). Therefore, the coordination of economic construction and environment has become one of the most important research topics. With the improvement of people's awareness of environmental protection, the prevention and control of geological disasters has been regarded as an important daily work of governments and management departments at all levels. The risk assessment and prediction of regional geological disasters is an important link in the prevention and control of geological disasters. It is very important to protect the safety of people's lives and property\(^2\). As early as the middle of last century, foreign geologists paid attention to the evaluation of regional geological disasters\(^3\). In the 1970s, the U.S. Department of land protection first assessed the risk of ten kinds of natural disasters in California, such as earthquakes and landslides, established a set of prediction models for natural disasters such as floods, earthquakes, typhoons and landslides, and issued various disaster reduction policies. China is one of the countries with the richest types of geological disasters in the world. It is also the country with the earliest systematic scientific record of geological disasters. However, due to the limitations of history, all the valuable historical records of geological disasters are lost\(^4\). The research on the evaluation and early warning of regional geological disasters in China started in the 1980s. The early research objects focused on the study of disaster distribution law, disaster formation mechanism and disaster early
warning. The geological types studied include hydrogeology, engineering geology. With the development of China's economy, the increase of investment in regional geological disaster research, and the development of GIS, China's geological disaster research gradually breaks the rules, and the level of evaluation and early warning is increasing.

2. Analysis of hidden danger characteristics of geological disasters

2.1 Types of regional geological disasters

For a specific area, geological disasters often have two basic characteristics: mass occurrence and several kinds of disasters associated. The group occurrence of debris flow disaster is the most significant. For example, the Xiaojiang River Basin in Southwest China, the Weihe River Basin in Northwest China and the laomaoshan area in Eastern Liaoning Province are all the heavy disaster areas of rainstorm type debris flow. During the rainstorm season, multiple valleys break out debris flow at the same time, forming regional geological disasters[5]. The reason is that the basic conditions of producing disastrous debris flow topography, lithology, geological structure and climate conditions have regional characteristics, resulting in the characteristics of regional mass occurrence of debris flow[6]. There are correlations among many kinds of geological disasters, for example, earthquake disasters often induce landslides and collapses; The collapse and slide disasters can provide a large number of material sources, which often aggravate the scale and intensity of debris flow disasters; The regional soil erosion has changed the natural environment and become the reserve condition for the formation of debris flow[6].

2.2 Algorithm of geological hazard impact index

Regional disaster scenario can be described by disaster consequence and its evolution trend: the state of disaster bearing body directly reflects the disaster consequence, and the relationship between disaster bearing bodies leads to complex and diverse evolution trend of disaster consequence[9]. Taking the disaster bearing body and its association as the core, a network model reflecting the characteristics of the disaster stricken area is constructed to describe the regional disaster scenario. In the classic "egg yolk" model of fuzzy space theory, each part of an uncertain region is labeled as egg, yolk and white, corresponding to the complete region, the clear part of the region and the uncertain part of the region respectively[10]. Therefore, referring to the fuzzy space theory, this paper proposes a "egg yolk" structure representation method of the disaster bearing body's influence range. The disaster bearing...
body and the disaster consequence diffusion range of the disaster bearing body are respectively marked as the yolk (Y) and yolk (W) of an egg. Then the spatial range of the disaster consequence influence of the disaster bearing body is the whole egg (E) composed of yolk and yolk, \( Y \cap W = E \), as shown in the figure 2.

![Fig. 2 "egg yolk" model of affected area of disaster bearing body](image)

When the disaster consequence of the disaster bearing body does not have the nature of diffusion, the egg white is empty. This method can not only reflect the evolution attribute of the state of disaster bearing bodies, but also help to analyze the influence relationship between disaster bearing bodies\(^{[11]}\). Using this method to construct disaster scenarios reflecting the characteristics of the disaster stricken area in advance is conducive to the assessment of disaster loss risk in advance and the deduction of disaster scenario evolution afterwards.

At present, people have a clear understanding of the disaster bearing body involved in a specific single disaster and its consequences; The research on disaster chain of multiple disasters has been carried out all the time. The deep reason for the formation of disaster chain is the result of the diffusion of disaster consequences along the association between disaster bearing bodies. In this paper, based on the study of disaster chain, a topological Association considering the influence range of disaster bearing bodies is defined to describe the relationship between regional disaster bearing bodies, which is called impact topological Association: if the disaster bearing body \( e_i \) and the disaster bearing body \( e_j \) are related to an event at the same time, and at least one state of disaster bearing body has the evolution attribute, if the other disaster bearing body is within the maximum influence range of the disaster consequence of the disaster bearing body, then there is influence topological association between the two disaster bearing bodies. Referring to the current emergency decision-making process, this paper analyzes the relationship between any target disaster bearing body in the region based on the spatial topological relationship theory. When we only consider the spatial topological relationship between the disaster bearing bodies without considering the diffusion property of the disaster consequences of the disaster bearing bodies, there are mainly five cases: separation, intersection, equality, inclusion and inclusion, as shown in the figure 3.

![Fig. 3 spatial topological relationship between disaster bearing bodies](image)
The disaster consequences of many disaster bearing bodies are diffuse, and their influence scope is far beyond the space scope of the disaster bearing bodies themselves, which determines that not only the contact disaster bearing bodies can influence each other, but only the spatial topological relationship between the disaster bearing bodies can not satisfy the judgment of the possibility of mutual influence between the disaster bearing bodies. Therefore, considering the evolution attribute of the disaster bearing body state, the basic spatial hidden danger distribution relationship is combined with the "egg yellow" model representation method of the disaster bearing body influence range, and the problem is transformed into the topological relationship analysis in fuzzy space. When analyzing other disaster bearing bodies that may be affected by disaster consequences, W(ej) can be ignored, and Y(ej)=E(ej), only the RCC relationship between Y(ei)−Y(ej) and E(ei)−Y(ej) needs to be considered

$$R = \left[ F\left( Y\left( \vec{e}_i \right), Y\left( \vec{e}_j \right) \right) / F\left( E\left( \vec{e}_i \right), Y\left( \vec{e}_j \right) \right) \right]$$

(1)

Based on the "egg yellow" model, the influence range of disaster bearing body is expressed. Based on the "egg yolk" model of the affected area of the disaster bearing body, considering the spread range of the disaster consequence under the most seriously damaged state of the disaster bearing body, the width of the egg white is determined, the maximum possible affected area of the disaster bearing body is calculated, and the affected area of the disaster bearing body and its disaster consequence is expressed as "egg yolk" form. Suppose that the damage location coordinate of the disaster bearing body ei is li=(lx, ly), and li∈Y(ej), then the diffusion range of disaster consequences of the disaster bearing body in the regional space under the Moore type neighborhood is as follows:

$$w\left( \vec{e}_j \right) = \{ l_o = (l_{ox}, l_{oy}) \mid \| l_{ox} - l_{ox} \| \leq ds(\vec{e}_j) \}$$

(2)

$$\| l_{oy} - l_{oy} \| \leq ds(\vec{e}_j), \left( l_{ox}, l_{oy} \right) \in \mathbb{Z}^*, o \neq i$$

(3)

Furthermore, the maximum impact range of disaster bearing bodies in regional space can be calculated.

$$E\left( \vec{e}_j \right) = Y\left( \vec{e}_j \right) \cup W\left( \vec{e}_j \right)$$

$$= Y\left( \vec{e}_j \right) \cup \bigcup_{l_i \in Y\left( \vec{e}_j \right)} w\left( \vec{e}_j \right)$$

(4)

From the perspective of scenario response, aiming at the reasoning of regional disaster evolution law and risk identification, taking the disaster bearing body as the node and the influence topological association between disaster bearing bodies as the edge, this paper studies the construction method of network model which can reflect the regional disaster scenario. Firstly, based on the regional disaster scenario construction, the regional elements are defined: disaster bearing body and the relationship between disaster bearing bodies.

2.3 The hidden danger characteristics of regional geological disasters

Through the comparison of the relative risks of different land use types, it can be seen that the land for facilities, industrial sites and public facilities in commercial service industry is the main land type with relatively concentrated relative risks in each region. It is mainly determined by the function and use of such land. There are often a large number of national assets or various potential sources of risk. As shown in the figure, the spatial dimension is the key disaster bearing body in the region, and the time dimension reflects the life cycle of the event. Different disaster bearing bodies may correspond to one or more disaster consequences at different stages of emergency. Therefore, the information of time and space factors for the development of emergency is the key basis for the decision-making of "scenario response" emergency management.
3. Analysis of experimental results

The core of disaster system disaster process is the dynamic process of disaster spatiotemporal change. The evolution of disaster scenario is reflected in the change of disaster consequences with time and the spread of spatial areas. In conclusion, within the scope of disaster prone space, the spatial distribution of disaster losses of different types is different. In cities, commercial land, industrial land and public facilities land in built-up area are relatively high risk areas. Therefore, the research on disaster scenario and its evolution for disaster loss risk assessment must fully consider the distribution of the organic whole in space composed of disaster bearing bodies and their different combination methods. With the life cycle of emergency, its influence diffusion has the characteristics of time series and evolution. Through the analysis of historical disaster information and relevant research results of life cycle theory of emergency, the impact diffusion of emergency can be divided into three types: immediate type, sudden type and soothing type. Under the joint action of natural extinction and emergency response measures, the impact diffusion of emergency events can be divided into three types, the influence trend is in line with the trend of curve in the figure5.
As we all know, the occurrence and development of emergencies follow a specific life cycle, which will go through the stages of occurrence, development and mitigation. At different times of the occurrence and development of emergencies, the disaster consequences of the disaster bearing body are not immutable. It may be that the disaster consequences have changed or there are new disaster consequences. Therefore, the disaster consequences faced by the emergency response are phased, and different emergency measures need to be taken to effectively deal with the disaster consequences at the current stage. Although the emergency plan clearly stipulates the emergency response measures, such as according to the emergency organization system and responsibilities or emergency response level, it is basically a static overall view, and ignores the phased nature of the emergency response measures over time. Therefore, decision makers not only need to deploy and plan from the overall perspective, but also should control the priorities of emergency management according to the different disaster consequences and their urgency in each stage of emergency occurrence and development, so as to ensure the orderly rescue work, optimize the allocation of emergency resources, and achieve high-speed and efficient "scenario response"

4. Conclusions
The evolution of regional geological disasters is complex and unpredictable, but through in-depth research and scientific scale effect analysis, through the data simulation statistics of different time and space scales of detection data, the establishment of statistical model, we can relatively improve the accuracy of regional geological disaster evaluation. With the improvement of human ability to transform nature and the destruction of natural environment caused by human activities, the occurrence rate of various extreme natural disasters is becoming more and more frequent, so that the evolution process of natural factors affecting geological disasters is accelerating rapidly; At the same time, with the establishment of geological disaster data statistics and early warning model, the ability of regional geological disaster evaluation in China is gradually improved.

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