

Research on the resilience assessment of Beijing urban area in response to flood disasters

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1 Introduction

1.1 Research Background

The current complex climate change has gradually exceeded the level of human control of natural disasters. Even in areas with strong emergency response capabilities, when faced with relatively uncertain environmental changes, it is inevitable to be caught off guard. The construction and evaluation of urban disaster prevention and resilience has gradually become the consensus of all countries in the world, and the construction of urban resilience projects has gradually received attention in various places. The ideal of urban resilience design also reflects all aspects of disaster risk response, urban safety engineering construction and urban green development. Building scientific, rational, effective and convincing urban resilience construction and promoting feasible resilience actions have become a consensus view of global development.

China has been deeply affected by flood disasters since ancient times. Water is not only the source of life, but also affects and destroys the production and life of human beings all the time. In mid-July 2021, major floods occurred successively in Zhengzhou, Xinxiang, Luoyang, Gongyi and other places in Henan, which seriously threatened the safety of people's property. A difficult one, P Plus support. Brothers from other provinces, including major companies and individuals, actively donated money and materials to help the disaster-stricken areas. The torrential rain disaster suffered by Henan this time can be said to be a once in a thousand years. Zhengzhou, the provincial capital, receives an average annual rainfall of 640.8 mm. But from July 19 to July 21, Zhengzhou received a total of 627 mm of rainfall, which is equivalent to the rainfall of the previous year in these three days. Due to the torrential rain, Zhengzhou's drainage system and underground pipelines were unable to discharge all the rainwater in time, resulting in urban waterlogging. Especially in low-lying areas, the water depth is more than 1.5 meters. As of 12:00 on August 2, 2021, 292 people were killed and 47 missing in Zhengzhou City. This particularly heavy casualty accident has brought our understanding of flood disasters to an unprecedented level. This major disaster is mainly due to the lack of an early warning mechanism, and people's lack of awareness of the severe rainstorm and flood disaster. The subway was still running during the heavy rain, but no closure measures were taken. A clear understanding of flood disasters and an accurate and scientific assessment of the city's ability to prevent disasters have become an important subject direction for the majority of scientific researchers.

1.2 Research purposes

With the abnormal changes in global meteorological conditions, the frequent

occurrence of extreme rainstorms, and the rapid progress of urbanization, the population and economic activities are concentrated, and the trend of flood disasters in my country has gradually become obvious. Cities are important transportation hubs for China's economic operation, society, and civilization development. Cities are densely populated and concentrated in property. If urban waterlogging occurs, it will have a huge impact and seriously inhibit the development of the social and national economy. Therefore, the problem of urban flood disaster prevention and mitigation has also attracted the attention of the international community, and urban flood disaster evaluation has increasingly become an important part of the entire flood response. The core of flood natural disaster management and disaster prevention and mitigation. The assessment of urban flood disaster prevention resilience is the precondition and cornerstone of understanding urban floods, an important management method for accurately judging the severity of disasters, and a solid foundation for the effective management of urban floods. The scientific research on flood disaster evaluation at home and abroad has developed vigorously and achieved fruitful results. This paper will deeply analyze the formation characteristics of urban flood disasters, study the realistic flood disaster assessment system and assessment model, visualize risk disasters, and put forward reasonable suggestions for the weak links in disaster areas.

1.3 Significance of research

The resilience assessment of urban flood disasters will help to promote the construction of flood safety and urban resilience in my country's urban areas. How to build a safe, reliable, systematic and reasonable urban flood disaster assessment system, and scientifically and accurately measure the flood risk in different regions. As far as possible when urban waterlogging occurs, it is necessary to ensure the life safety of urban people and reduce property losses. Therefore, it is of great significance to carry out flood disaster resilience assessment and weak link prevention strategy research.

First of all, with the healthy and efficient operation and development of the market economy and the rapid development of social and social infrastructure construction, my country has carried out evaluation and response to urban floods and waterlogging disasters. In terms of life safety and maintaining community harmony and stability, it will highlight its important strategic position and significance. Secondly, the evaluation and response to urban flood disasters is also a major requirement for improving the image of the government. The government is the subject of the administrative market, while citizens are the object of administration. The so-called government image is the organic reflection of the market subject in the brain of the object. An excellent government image is the key foundation for the people to trust government departments. As the manager of public affairs, the government has the responsibility, obligation and ability to evaluate, predict and manage various natural disaster events.

This paper studies the resilience of urban floods. Based on the resilience theory, this paper takes urban flood disasters as the research object, based on the entropy

weight method and the TOPSIS method, and comprehensively considers the natural geographical conditions, the degree of urban construction and social emergency management. In order to provide a scientific basis for the prevention and control of flood disasters in urban areas, the evaluation index system and evaluation model of resilience to flood disasters are constructed. At the same time, on the basis of the evaluation, the flood resilience capacity of Beijing is predicted to understand the future development situation that the current development mode may bring, and enrich the resilience assessment theory of urban flood disasters. On the basis of evaluation and prediction, focusing on the theoretical basis and top-level design of urban flood resilience, enrich the flood disaster assessment model and the theoretical system of urban flood disaster assessment, and provide a theoretical framework for the planning of urban flood control.

2 Literature Review

2.1 Research Status of Urban Floods at Home and Abroad

Since the 21st century, global warming has continued to intensify, resulting in rising sea levels. In particular, the intensity and frequency of heavy rains in extreme weather has become more and more frequent. The combined impact on cities will cause disasters in the region where they are located. The scope of influence is getting wider and wider. Floods are one of the most common natural disasters in many parts of the world and are attracting increasing public attention. Because cities are densely populated and mostly close to water sources, urban floods have deeply affected national development, people's lives and property safety.

Traditional flood management methods are not enough to deal with the uncertainty of the future. Many foreign scholars have used various factors that affect the formation of disasters as research indicators to find new strategies to deal with them. Yashon et al. ^[1] used Analytic Hierarchy Process (AHP) and ArcGIS technology to select and integrate some flood causative factors, such as rainfall distribution, elevation and slope, drainage network and density, land use/land cover and soil type indicators, to identify urban The Flood Risk Index is an urban flood risk assessment zoning for Eldoret, Kenya. Liu et al. ^[2] comprehensively considered the main indicators of the study area, including rainfall, topography, land use, vegetation, river network density, population and For strength, the above factors were normalized using a geographic information system (GIS) to obtain standardized multi-source raster data. According to the analytic hierarchy process, the weights of relevant indicators are determined, a comprehensive flood risk assessment model is constructed, and the disaster impact assessment is carried out. Based on the two basic concepts of disaster and vulnerability, Chakraborty et al. ^[3] observed and evaluated the spatial characteristics of the Flood Hazard Index (FHI) and the Flood Vulnerability Index (FVI) with the help of the AHP, in the GIS environment. The Flood Risk Index (FRI) is jointly defined and an example evaluation of flood risk in the Kuchhar area is carried out. Resilience (resilience) thinking has become a way for scholars to study the resilience of cities to floods, and while there are many different

concepts of resilience, most authors agree that flood-resilient cities will have lower flood consequences if flooding occurs .

Some scholars have simulated and analyzed flood disasters: Yin Jie proposed a numerical analysis of flooding, and used a high-resolution 2D hydraulic model to evaluate the impact of land subsidence on urban flood risk ^[4]; Bidur Ghimire et al. A new method for 2D modeling by cellular automata^[5], which applies general rules to local neighborhood cells to simulate the spatiotemporal evolution of rainfall; Roland Löwe proposed a method for systematically evaluating flood risk adaptation options under an uncertain future. The framework^[6]adopts the agent-based urban development model DAnCE4Water and the 1D-2D hydrodynamic model MIKE FLOOD.

Domestic scholars' research on urban floods mostly focuses on the formation mechanism of disasters and the assessment of flood disasters. According to the analysis of climate data resources and social development data in a certain period of time, Liu Lanfang scientifically believes that floods are the result of the synergistic coupling of natural driving forces and human driving forces under specific spatial and temporal conditions ^[7]; Two main basic aspects of disaster reduction capacity are considered, and by selecting four main basic aspects: national economic vulnerability, population vulnerability, natural environment sensitivity and social vulnerability, the urban disaster resistance force is investigated and studied ^[8]; The analytic hierarchy process (AHP) improved by the entropy method analyzes the rainstorm disasters in the main stream of the Huaihe River, and analyzes the vulnerability distribution characteristics of the disaster-bearing bodies in the region ^[9]. Xu Zongxue and other scholars analyzed and studied the formation mechanism of urban flood disasters from the aspects of disaster-causing factors, disaster-pregnant environment, and disaster-bearing bodies ^[10]; The concept of vulnerability is constructed and analyzed ^[11]. Zhang Hui believes that the main content of urban flood disaster management has changed from engineering defensive measures to flood risk management ^[12]; Wu Yuyan used the entropy method to evaluate the vulnerability of flood disasters in three aspects: precipitation during flood season, topography and socio-economic factors. The results were analyzed^[13]; Li Guoqing used the AHP method to study the risk of rainstorm and flood in different communities during the future social reconstruction period of Xiongan New Area based on the three indicators of group vulnerability, community organization and facility disaster prevention^[14]; Wang Qun The fuzzy set pair analysis method is used to construct an urban flood vulnerability assessment model in the Yangtze River Economic Belt ^[15]. Hou Qianqian comprehensively used the distributed hydrological model (SWAT) and the storm flood management model (SWMM) to establish a coupling method of watershed runoff simulation and urban runoff simulation^[16]. In this regard, specific countermeasures and measures to reduce vulnerability are proposed ^[17].

2.2 Research status of urban resilience theory at home and abroad

In the application fields of urban disaster prevention and mitigation, domestic and foreign experts and scholars have carried out some basic theoretical knowledge and basic technical framework construction exploration work on the construction of

resilient urban engineering, and have gained a certain degree of understanding. The concept of "Resilient Cities" was first proposed at the United Nations Global Summit on Continuing Economic Development in 2002, and under the active promotion of the institution, the scientific research on resilient cities has been further enriched. As for the definition of resilient city, various experts and scholars have different views. In general, scientists generally believe that a resilient city is a city that can resist disasters and reduce disaster losses by virtue of its own capabilities, and quickly restore the city to its basic operating state by rationally allocating resources. Lawrence et al. studied how modern cities recover from disasters^[18], adhering to the "resilience theory" for resilient cities. Giulio Zuccaro believes that an "all-hazards" approach that addresses multiple risk conditions (including Natech and cascading effects) and integrates DRR and CCA design strategies shows the potential to be highly cost-effective^[19], maximizing the effect of complementary measures, And optimize, mitigate, and adapt to changes within a multi-scale elastic perspective. Enjalbert Simon starts from the human-machine system and the concept of green, ecological, sustainable and smart city^[20], aggregates on the concept of resilient city, develops a model of urban traffic control system, and builds urban resilience in an intelligent way.

Although the definitions of resilient cities are different, the views of various researchers are basically the same. After the relevant literature research and the analysis of the existing "resilient city", it can be seen that the explanations of the resilient city from various perspectives are basically the same in terms of the logical structure of theoretical thinking and the main content. It is hoped that through the advancement of architectural design and the improvement of construction technology, it will strengthen the effective mutual integration with social aspects such as public participation and urban system innovation, so as to establish a close and efficient urban information system. In the face of uncertain risk conditions, resilient city construction can more effectively enhance the city's overall disaster prevention and enhance the urban system's adaptability to natural disasters. In general, the research theories on the construction of resilient cities have a history of vigorous development in foreign countries for more than a few decades, while China's attention and research on resilient cities obviously lag behind international research and are in a relatively infancy. As far as research content is concerned, current research in China mainly focuses on the introduction of urban construction concepts, the development mechanism, and the establishment of basic theoretical frameworks. For example, Fang Dongping^[21], Bing Qiliang^[22], Wang Xiangrong^[23] and others defined the concept of resilient city based on evolution resilience, ecological resilience and engineering resilience respectively; The ability of sustainable development is separated from the basic connotation of resilient city, and its specific connotation is introduced separately^[24]; while Ni Xiaolu et al. have summarized the current well-known and mature theoretical framework of resilient city in foreign countries^[25]. The development of a resilient city construction evaluation system provides valuable advice and suggestions, and advocates the integration of the tenets of ICT and economic development into the theoretical framework of resilience. Wu Jia believes

that urban resilience is not only a technical issue that needs to be discussed in the planning and design process, but also an administrative issue with public attributes that focuses on organizational coordination and governance capabilities [26]. Urban resilience in the perspective of public administration should adhere to the idea of first assessing and then responding to governance can reveal the general and regular characteristics of administrative organizations in the face of disasters and difficulties.

In terms of scientific research methods, although the current research results on resilient cities are mostly based on qualitative analysis, qualitative analysis cannot accurately evaluate and analyze the current development status of cities, and it is difficult to conduct comparative studies with other cities. Quantitative research is the trend of future research. The resilience assessment link is the main link in the concept construction of a resilient city. It solves the basic question of "resilience" and helps managers form a reasonable understanding of the city's current resilience level. Although the resilience theoretical research framework of the urban system has been basically formed, due to the lack of deep thinking on the correlation and cross-coupling relationship between indicators in many scientific research theoretical frameworks, the existence of feedback between indicators is often ignored, which makes the research and analysis results inconsistent. correct. The main quantitative evaluation tools include threshold analysis method, social network model, breaking point method, etc. However, most of the practical problems faced are single object. Methods such as index analysis, linear regression, etc. refine the calculation of the model, and are more suitable for the quantification of qualitative indicators and specialized network science, because the quantification of qualitative indicators requires scientific research objects to have abundant database information resources. Lack of complete database resources.

From the perspective of scientific research, the current research perspective is relatively simple, and most of them focus on the material and technical aspects of resilience, while less consideration is given to soft measures such as public security construction, emergency management of emergencies, and national policy measures. At present, most of the basic theoretical research and experimental results at home and abroad fully apply the theory of resilience technology to urban and rural development planning projects in terms of land, environment, urban landscape, etc. There are relatively few achievements in disaster reduction space and emergency management of emergencies.

2.3 Current status of domestic and foreign research on flood disaster assessment model

Urban floods have gradually become one of the natural disasters that affect urban economic and social development, and there are more and more studies on flood prevention and mitigation. Assessing the risk of urban flood disasters can provide a reference for risk response and management, and ensure the safety of people's lives and properties. The flood disaster risk assessment methods used in the current research can be divided into three types: one is flood disaster assessment based on historical disaster data, the second is flood disaster risk assessment based on index system, and the third is flood disaster risk assessment through GIS technology and

remote sensing technology. Disaster Risk Assessment.

The flood disaster assessment method based on historical disaster data mainly uses statistics of historical flood disaster data, builds a flood disaster case database, determines the probability of disaster occurrence and its influencing factors, and evaluates flood disaster risk based on this. Liu Xinli et al.^[27] used the historical flood disaster data in the Yangtze River Basin as the basic data, and applied the Markov chain model to analyze and evaluate the flood disaster risk in the Yangtze River Basin. BARREDO^[28] used Munich Re and EM-DAT, two global public natural disaster databases, to determine the impact of flood disasters on social and economic development by selecting two indicators of casualties and economic losses. YU et al.^[29] used historical flood and rainfall data in the middle and lower reaches of the Yangtze River in recent years, analyzed the characteristics of historical flood, and analyzed the relationship between it and rainfall, which can be considered as a positive correlation. The flood disaster risk assessment based on the index system is the most widely used. By exploring the factors that lead to flood disasters as indicators of risk assessment, an appropriate evaluation method is selected to assess the flood disaster risk in the study area. Lai Chengguang et al.^[30], Wang et al.^[31] constructed a flood risk assessment model based on the random forest intelligent algorithm, selecting 10 evaluation indicators such as rainfall, slope, and elevation. Subsequently, LAI proposed a flood risk zoning model based on ant colony rule mining algorithm^[32]. Wang He et al.^[33] established a comprehensive evaluation model of urban flood risk under extreme rainstorms using the normal cloud model, and selected factors such as the maximum 24-hour rainfall, inundation duration, and disaster-affected population rate as evaluation indicators. Shen Haiyan et al.^[34] used the AHP-fuzzy comprehensive evaluation method to evaluate the flood disaster risk. Wan Xichao et al.^[35] selected the risk of disaster-causing factors, the sensitivity of the disaster-pregnant environment, the vulnerability of the hazard-bearing body, and the ability to prevent and reduce disasters as the first-level evaluation indicators, and the following 13 specific indicators were used as the second-level evaluation indicators. A cloud model-based rainstorm and flood disaster risk assessment model is constructed. Mao Dehua et al.^[36] diagnosed the vulnerability of flood disasters in Hunan from the aspects of disaster environmental variability and socio-economic disaster sensitivity, and made a quantitative assessment of flood vulnerability.

Flood disaster risk assessment based on GIS technology and remote sensing technology mainly relies on satellite remote sensing monitoring technology to obtain important disaster information, and uses the spatial analysis function of GIS technology to evaluate flood disaster risk combined with ground elevation data. MONIRUL et al.^[37] used GIS technology combined with the maximum likelihood method to extract the flood inundation depth data contained in the NOAA AVHRR image to evaluate the flood risk in Bangladesh. SANYAL^[38] used GIS technology to extract the flood remote sensing images that occurred in West Bengal, India in 2000, and used the inundation information in the flood disaster vulnerability assessment of residential settlements. Tang Chuan et al.^[39] obtained high-resolution remote sensing images through GIS technology, and used them as data sources to identify urban land

cover types, and then to assess the loss and risk of urban flash flood disasters. HUANG et al. ^[40] extracted the inundation range information in the remote sensing images of Jiangsu flood disasters in 1991, 2003 and 2007 through GIS technology, and used the inundation times as the standard to evaluate and analyze the regional flood risk.

2.4 Review of domestic and foreign research

Domestic and foreign research on urban flood disasters and urban resilience has made some progress, but there are few studies on the evaluation of flood disaster prevention capabilities based on urban resilience theory. The shortcomings of the research results are mainly reflected in the following aspects: (1) Scholars at home and abroad There are many studies evaluating urban resilience, but from the perspective of urban resilience, there are few studies evaluating a certain disaster. (2) At present, there are roughly three types of flood risk assessment methods. After summarizing the research work on flood risk assessment at home and abroad, the more common urban flood assessment methods at this stage can include three categories: one is the use of historical disasters. Statistical analysis and calculation, and then gradually carry out urban flood disaster assessment, the second is to evaluate the risk of urban flood disasters through index reflection, and the third is to use GIS technology and remote sensing technology to carry out risk assessment of flood disasters.

3 Methods

3.1 Research content

By drawing on domestic and foreign studies on urban resilience and flood disasters, this paper takes Beijing as the research object. Based on the specific situation of Beijing's urban area flood disasters, this paper evaluates and studies the resilience of Beijing's flood disasters. situation is predicted. The research content mainly includes the following aspects:

(1) Using literature search and consulting a large number of relevant flood disaster data, summarize the evaluation index system of domestic and foreign scholars on urban flood disaster resilience. Based on the entropy weight method and the TOPSIS method, the natural geographical conditions, the degree of urban construction and social emergency are comprehensively considered. Management and other factors, build an evaluation index system and evaluation model for flood disaster resilience, and then study and analyze the resilience of urban flood disasters. Considering the characteristics of flood disasters in urban areas, and studying the impact process of urban systems and the characteristics of time stages of flood disasters, starting from the four levels of resistance resilience, bearing resilience, resilience resilience, and learning resilience, Wuhan City 13 The flood resilience capability of each administrative district was evaluated, and the flood resilience capability was visualized through ArcGIS software.

(2) Through the evaluation and research on the flood resilience capability of Beijing

from 2010 to 2020, the development law and spatial distribution characteristic value of resilience capability were longitudinally explored, and the resistance resilience, bearing resilience and recovery of urban flood disasters were analyzed in depth. The correlation between resilience and learning resilience and the key factors affecting resilience, multi-level and objective assessment of the influencing factors of urban flood resilience in Wuhan City, and at the same time, based on the characteristics of time series, analyze and predict Wuhan in the next three years. Changes in the city's flood resilience and understanding of future development trends.

(3) Evaluate and analyze the flood resilience of urban areas in Beijing from 2010 to 2020, understand the development of flood disaster management in Wuhan, and put forward scientific and reasonable suggestions, so as to improve Beijing's urban safety level and strengthen the city's flood control. It provides a basis for the formulation of urban safety management policies by relevant departments, and also provides decision-making models and method references for the evaluation and research on urban flood disasters.

3.2 Research methods

Urban flood resilience assessment research involves urban resilience theory, ecological theory, statistical theory, mathematical theory, etc., and has a certain degree of overlap. Therefore, this paper mainly adopts the following research methods:

(1) Data collection method

Through the collection of various data related to the natural environment, social economy and energy structure of the study area by the Department of Land and Resources, the Bureau of Statistics and other departments, we can understand the current situation and characteristics of the geographical environment in the urban area of Beijing, and preliminarily determine the various types of flood disasters affecting the urban area. factors, as the basis for the construction of the evaluation index system, to further facilitate the development of research.

(2) Literature review method

By reviewing and sorting out relevant literature on urban flood resilience at home and abroad, this paper summarizes the research results that previous scholars have achieved, conducts analysis and research, and makes corrections and revisions to its deficiencies. By consulting the literature, we can quickly grasp the current research progress in this field and revise whether the direction of our research has scientific and practical significance. This is also beneficial for us to combine the current research frontiers of urban disaster prevention and resilience theory to enrich the theory of flood disaster resilience assessment, so as to propose the research content and method model of this paper. The literature review method in this study is mainly reflected in the analysis of domestic and foreign literature and legal policies, the study of domestic and foreign flood resilience assessment index systems, and how to collect and analyze index data.

(3) System analysis method

Urban flood resilience assessment is a complex systematic project, including

natural environment, social economy, emergency management and other factors. The urban regional flood resilience system builds an evaluation index system to make reasonable evaluations and related predictions.

(4) Mathematical model method

In the process of evaluating and predicting the resilience of floods in Beijing, it is necessary to use accurate mathematical models, mainly including entropy weight method and TOPSIS model. The TOPSIS model has many advantages, not only not limited by the size of the sample, but also not affected by the restriction of the order selection. The basic principle of its computational mathematics is to make the best ranking of the evaluation object by estimating the gap between the evaluation object and the better solution and the worst solution. In the TOPSIS method, the determination of the weight ratio has a huge impact on the credibility of the overall comprehensive evaluation results, because the entropy weight method uses the entropy value to measure the degree of dispersion of a technical index, and the smaller the entropy value, the higher the technical index. The greater the degree of dispersion, the greater the impact on the overall comprehensive score of the technical index, so we mainly use the entropy weight method to weight the overall comprehensive evaluation index. By calculating the disaster prevention and resilience capability of Beijing from 2010 to 2020, the flood prevention resilience capability of Beijing in the next 3 years is predicted by the combination of GM(1,1) and BP neural network model. The gray dynamic model is based on the gray time function concept as the historical background, and its core is the differential fitting thinking, that is, the time sequence is transformed into a differential equation, and then the method of the abstract system of differential equations is transformed into a dynamic model. The BP neural network is a mathematical model that does not define the mapping relationship between the input and output in advance. It can achieve the result that is closest to the target injection or output value when the input output value is given.

3.3 Technical route

Figure 1 shows the technical road map of this paper.

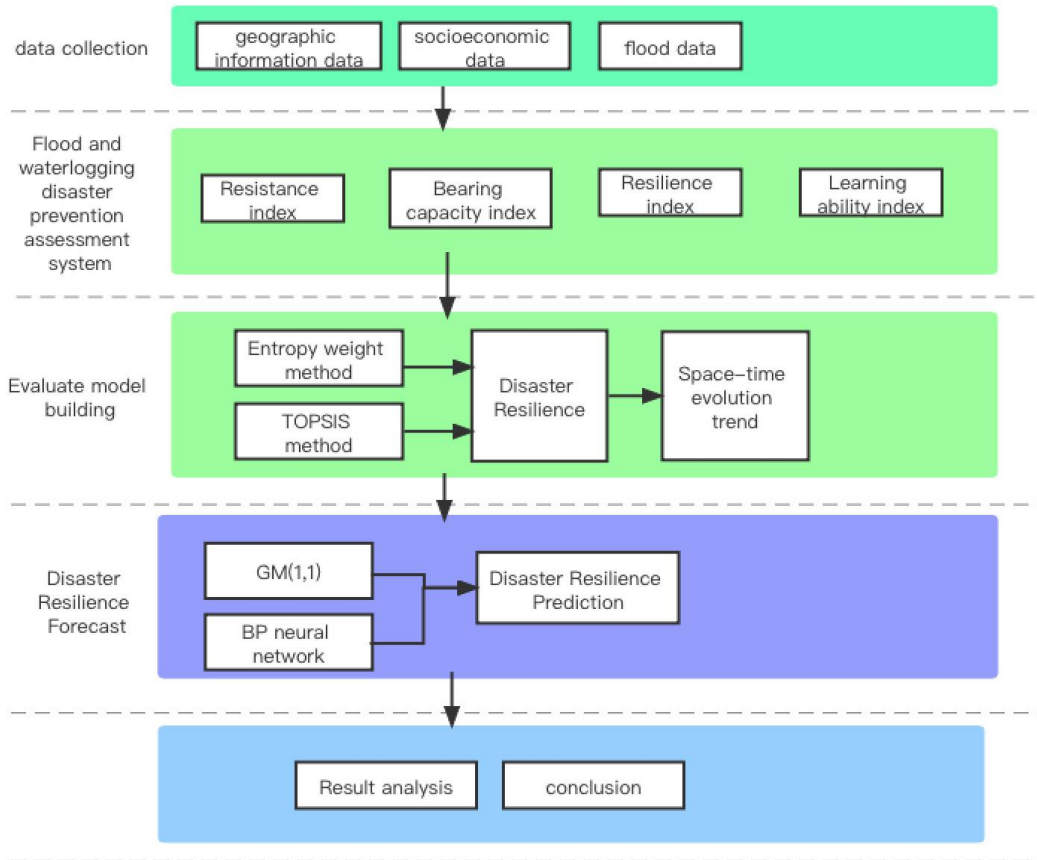


Figure 1 Technical route

4 Results

Starting from the resilience theory, this paper takes urban flood disasters as the research object, based on the entropy weight method and the TOPSIS method, and comprehensively considers factors such as natural geographical conditions, the degree of urban construction and social emergency management, and constructs an evaluation index for flood disaster bearing capacity. system and evaluation model, and then to study and analyze the disaster bearing capacity of urban flood disasters, and provide a scientific basis for the prevention and control of urban flood disasters. Then, based on the grey prediction and the BP neural network prediction model, the flood disaster data in Beijing in the past 10 years is used for prediction and analysis, and the resilience level of flood prevention and disaster prevention in Beijing in the next three years is obtained.

5 Evaluation

Domestic research on the evaluation of urban flood prevention resilience is still in its infancy, and there are few researches on urban disaster prevention resilience. At the same time, the impact and destructive power of flood disasters on cities in real life is shocking, and it will cause serious damage to people's lives and property safety. Therefore, the research on urban disaster resilience has strong practical significance and urgency. The innovation of this paper is based on a series of response

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