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Urban Resilience Evaluation and Optimization Research based on Rainfall Scenarios

-- Taking Bengbu City as an Example

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Abstract: The development process of urbanization has changed the natural factors such as topography, geomorphology, and bit difference, which increases the risk of urban storm flooding in case of extreme weather. The concept of urban resilience can guide urban planning and construction to resist rain and flood disasters and improve urban rain and flood safety resilience capacity. In order to effectively assess the level of urban rain and flood resilience, and effectively tap the key impact factors of resilience, this project takes Bengbu City as an example, and analyzes the urban infrastructure construction, economic and social development, urban ecological environment and hydrological situation of Bengbu City in recent years, constructs a comprehensive assessment model of urban rain and flood resilience, obtains the level of rain and flood safety resilience and key constraints in Bengbu City, and looks for optimization of the management of urban flooding, and find the effective implementation path to optimize the management of urban flooding.

Keywords: Urban Resilience; Stormwater Flooding; Resilience Assessment.

1. Introduction

As global climate change intensifies, it leads to drastic changes in the hydrological situation, an increase in the uncertainty of hydrological systems, and a sudden increase in the frequency and intensity of extreme weather events. In the process of promoting urbanization in urban areas, the natural conditions of local terrain, landforms and geology have been heavily modified, and the expansion of cities has led to an increase in flood losses, a diversification of the factors of flood losses, and a greater proportion of losses caused by internal flooding [1]. In addition, urban flooding in China has become more frequent with the advancement of urbanization, and the increase in the level of urbanization has led to an increase in flood losses and a significant rise in the number of people affected by urban disasters [2].

Stormwater flooding is an urban waterlogging or flooding phenomenon caused by rainfall, usually resulting in damage to urban infrastructure and socio-economic systems. Cities are more concentrated in terms of population compared to the countryside, and are more enriched by the damage caused by extreme weather, with about 50% of the population and 70% of property in China exposed to the threat of waterlogging [3]. In order to better cope with shocks from natural disasters, the concept of urban resilience has been proposed. Urban resilience refers to the ability of an urban system to withstand internal and external shocks, stresses, or uncertainties, as well as its ability to maintain its basic functions in response to these challenges, to quickly return to normal operation, and to adapt to new conditions.

According to the data of China's Flood and Drought Disaster Bulletin from 2011-2018, the average number of cities in China that are inundated with water or experience severe flooding is 154 per year, and flooding is more frequent in the Huaihe River Basin [4]. The problem of urban flooding in China has been highlighted, and the severe floods that have occurred in many places have damaged the city's infrastructure, caused a large number of economic losses and casualties, and adversely affected the normal functioning of the city and the safety of the citizens. Considering that the overall urban system consists of multiple subsystems interacting with each other, how to improve safety resilience and thus urban resilience by adjusting rainfall and flooding resilience is a major hotspot in the current urban resilience development. Because Bengbu is close to the Huaihe River Basin, Bengbu is selected as the research object, and through the analysis of various indicators of the city of Bengbu, a set of urban flood resilience evaluation system is established to derive the influencing factors for optimizing the urban resilience development, and to provide reference for the future urban resilience development.

2. Literature Review

The frequent occurrence of modern extreme weather disasters makes cities face natural disasters need more adequate preparation, and can quickly adapt to and mitigate the impact of disasters, which many scholars have carried out research, and found that the main causes of urban flooding disasters are: the frequency of urban rainstorms, the weakening of the capacity of the rainwater storage, the destruction of the water cycle system, urban planning and construction of irrational mechanisms [5]. In order to effectively solve the problem of urban flooding, Li Ya [6] and other scholars have proposed the construction of a quantitative resilience system for the assessment of strategic research, and scholars have been applying the relevant theories to the analysis of a particular city, Zhou Zhenhong [7] and other Hefei City as an example, the construction of the

PSR-TOPSIS integrated assessment model points out that the process of urbanization needs to enhance the resilience of the infrastructure, and should also pay attention to economic resilience of the growth of the city, and at the same time pay attention to the ecological and environmental resources. The PSR-TOPSIS comprehensive assessment model points out that the urbanization process needs to improve infrastructure resilience, pay attention to economic resilience growth, and pay attention to ecological resources. Jiang Yuzhan [8] used AHP-integrated fuzzy analysis to construct a community flood disaster resilience evaluation system, Huang Mei et al. [9] conducted a research on Changsha city by establishing an urban water ecology network based on MSPA model and MCR model, and Wang Huazhi et al. [10] put forward urban resilience suggestions through the perspective of urban flood risk identification and early warning. At this stage, domestic and foreign scholars for the urban resilience assessment in the context of urban flooding at home and abroad are the most widely used hierarchical analysis, expert scoring, fuzzy analysis, entropy weighting method, approaching the ideal solution ranking method (KL-TOPSIS) and so on. Zhao Ruidong et al. [11] discussed the research of urban resilience in various aspects on the basis of outlining the research origin and conceptual connotation of urban resilience; Zhou Limin [12] constructed the indicators of urban resilience from the perspective of international cases, which provided a wider research perspective; Chen Yumei and Li Kangcheng [13] researched urban resilience from the perspective of foreign public management, and Zheng Yan et al. [14] selected the sponge city pilots of the whole country for investigation, and constructed a more representative indicator system; Chen Changcheng and Li Kangcheng studied urban resilience under the perspective of foreign public management; Zheng Yan et al. selected the sponge city pilots of the whole country for inquiry, and constructed a more Chen Changkun et al. [15] established a resilience assessment model for rain and flood scenarios based on the three attributes of resistance, resilience and adaptability; Chen Xiaohonget al. [16] analyzed the spatial-temporal evolution of urban resilience in the northeast region; and Ni Xiaolu and Lai Xingqiang [17] explored the future direction of the development of the urban resilience system.

Although the existing research results have made some progress, there are still a large number of vacancies in the field of urban stormwater resilience research. Based on this, this project constructs an urban resilience assessment model based on an example of the hydraulic situation in Bengbu City, which enriches the research in related fields.

3. Construction of the Indicator System

Based on the existing research foundations at home and abroad, this paper identifies indicators from four dimensions: resource, economic, ecological, and social. The resource dimension considers the sustainability and management efficiency of water, energy, and land resources; the economic dimension focuses on the diversification of the city's economy, its financial health, and its capacity to innovate; the ecological dimension measures the diversity of the city's ecosystems, its climatic adaptability, and its recycling of resources; and the social dimension focuses on the development of the city's The social dimension focuses on the coordination of urban development and the ideology of residents. This multi-level assessment framework contributes to a comprehensive understanding of urban resilience and provides a basis for the development of integrated urban planning and policies. Through this integrated approach, the complex challenges facing cities can be better addressed and sustainable urban development promoted. The resilience system is constructed from the three aspects of urban resistance, resilience and adaptability, with urban resilience as the main body of the study, referring to existing expert scores and combining cases to establish the urban resilience indicator system, as shown in Table 1.

Table 1. System of urban resilience indicators

Research system	Evaluation dimension	Evaluation indicators	Unit (of measure)
Urban resilience	Economic resilience (0.2764)	GDP per capita	Yuan/person
		Amount of foreign capital actually utilized	ten thousand dollars
		GDP growth rate	%
		Gross industrial output value above scale	ten thousand dollars
	Social resilience (0.2234)	General higher education enrolment per 10,000 population	man
		Health technicians per 10,000 population	man
		Urban registered unemployment rate	%
		natural population growth rate	%
	Ecological toughness (0.2258)	Green space coverage in built-up areas	%
		Green space per capita in parks	Person/square meter
		Municipal waste disposal capacity	kg
	Resource resilience (0.2744)	Number of beds	sheet of paper
		Number of medical institutions	classifier for individual things or people, general, catch-all classifier
		Road space per capita	square meter

Based on the above indicators established, relevant data are collected and analyzed.

4. Conclusion and Recommendations

This paper constructs urban resilience indicators for coping with sudden-onset natural disasters such as floods in the context of cities and rain and floods, analyzes the impacts of various dimensions on urban resilience and encapsulates them, and draws the corresponding conclusions and recommendations. In the context of the indicators measured according to the context, targeted recommendations are made.

4.1. Increase the Promotion of Sponge City Applications

The sponge city concept effectively solves the problems faced by cities in stormwater management, flood prevention and urban environment improvement through the

construction of green infrastructure and sustainable urban design, and enhances the resilience of cities to disasters. Increased promotion of sponge cities has significant advantages in improving urban resilience. By building green infrastructure, improving water management efficiency, and improving urban ecosystems, sponge cities can not only effectively mitigate rainwater-induced flooding, but also improve the overall resilience of cities. Their unique design concepts minimize urban interference with the natural environment, help conserve natural resources, and improve the stability of urban ecosystems. In addition, by slowing down rainwater runoff, sponge cities help improve urban water quality and reduce the risk of water pollution. Taken together, increasing the promotion of sponge cities is not only in line with the principles of sustainable urban development, but also provides strong support for improving urban resilience and responding to climate change and extreme weather events.

4.2. Gradually Transforming from the Traditional "Government-Led" and "Flood-Drainage Project-Led" Paths to the Self-Regulating Governance of Urban Engineering Ecology

Traditionally, the enhancement of urban resilience has relied heavily on government-led and large-scale drainage projects. However, with the growing concern for urban sustainability and ecological balance, this path is gradually shifting towards self-regulating governance of urban engineering ecology. The new concept emphasizes using nature as a teacher to make cities better adapt to environmental changes and mitigate the risk of flooding through the construction of green infrastructures, nature reserve areas and ecological landscapes. This shift emphasizes the value of ecosystem services to achieve more sustainable and resilient urban development by stimulating the city's intrinsic self-regulation mechanisms and improving its adaptability in the face of extreme climate events and water management. This shift not only reduces the overreliance on traditional engineering, but also promotes urban planning that focuses more on the symbiosis between nature and the city, opening up innovative and sustainable development paths to increase urban resilience.

4.3. Increase the Awareness of the Government and Citizens on Flood Prevention and Control, Emergency Response Awareness

The government can take measures to improve urban resilience, including establishing a sound flood prevention and control system, strengthening the monitoring and early warning mechanism, planning a rational urban drainage system, and developing a flexible and responsive emergency response plan. At the same time, through publicity and education campaigns, the government can raise the level of public awareness of flooding and emphasize the importance of prevention and response. Citizen participation is crucial as they need to understand the emergency response procedures, respond positively to early warning messages, and take appropriate measures to safeguard their own safety. Increasing government and citizen awareness of flood prevention and control will form an organic and cooperative mechanism to improve the overall resilience of the city and achieve a more resilient urban community. This joint strengthening of awareness not only reduces the potential impact of flooding, but also creates a stronger foundation for sustainable urban development.

4.4. Integrate Technical and Social Dimensions to Maximize the Utility of Urban Resilience

On the technological side, the introduction of advanced smart city technologies, big data analytics and Internet of Things (IoT) devices can enable real-time monitoring and early warning systems and improve the speed of urban response to natural disasters and emergencies. At the same time, the social dimension is equally crucial, including the education, training and participation of urban residents. The social dimension of resilience is reflected in the establishment of tight community networks, raising residents' awareness of disaster risks, and fostering a sense of cooperation during emergencies. By combining technology and society, cities can understand and respond to all types of challenges in a more holistic manner, maximizing the potential of urban resilience through synergy. This integrated approach not only enhances urban resilience, but also provides a solid foundation for more sustainable development in a changing environment.

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