Study on the Construction of Haikou's Urban Disaster Prevention System from the Perspective of Safety Resilience

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Abstract: The construction of a safe and resilient city is a crucial measure to ensure urban safety. It is of great significance for enhancing a city's ability to respond to sudden risk impacts, creating a high-quality livable environment, and improving the quality of life. Traditional disaster prevention planning focuses on the construction of engineering defense facilities, which struggles to address the uncertain risks brought by climate change. Taking Haikou City as the research object, this study, combined with the theoretical framework of "safety resilience", puts forward ideas for building Haikou into a resilient city from three dimensions — social, spatial, and temporal — and formulates a multi-stakeholder collaborative governance mechanism involving the government and society. This research aims to provide innovative methods and new ideas for constructing disaster prevention systems in tropical coastal cities.
***Keywords*:** safety resilience; disaster prevention planning; Haikou city; multi-dimensional collaboration

1. Introduction

Against the backdrop of increasing instability in the global climate system, compound disaster events have become more frequent. In 2022, the strong tropical storm "Chaba" affected 35,500 people in Hainan Province, caused 2 deaths, and resulted in direct economic losses of 183 million yuan. This disaster fully exposed the shortcomings of the current urban safety guarantee system. As a strategic pivot for maritime cooperation under the "Belt and Road" Initiative, Haikou City, due to its unique geographical location, faces multiple pressures from typhoons, compound floods, and earthquake disaster chains. Constructing a resilient urban safety defense system has thus become a key issue for ensuring the region's sustainable development. Faced with these dual challenges, how to achieve the coordination between safety resilience goals and high-quality development demands through innovations in spatial planning technology has become a core topic for optimizing the effectiveness of territorial spatial governance[1].

2. Theoretical Origin and International Practice

The formation and evolution of the theoretical system of urban resilience can be traced back to the late 20th century. With the rise of the complex scientific paradigm, the concept of resilience gradually extended to the field of urban system research in the 1990s. At the turn of the century, the academic community formally established the theoretical framework of "resilient cities" for the first time in the field of ecology, marking the entry of urban safety research into the stage of systematic thinking[2]. The international community's institutionalization of this theory began with the signing of the Global Framework for Disaster Reduction in 2005, whose core essence lies in enhancing regional risk resistance capabilities through multi-dimensional capacity building. With the establishment of the global development goal system under the *2030 Agenda for Sustainable Development*, urban resilience — regarded as a key path to reconcile the contradiction between safety and development — was incorporated into the core agenda of modern urban governance. In particular, the urban sustainable development guideline released in 2016 explicitly identified the construction of ecological resilience as the benchmark orientation for the transformation of spatial planning.

3. Haikou's Resilient City Construction System

Multi-dimensional collaboration is essential for building an urban resilience defense system. We should move beyond the traditional focus solely on engineering and municipal planning, and systematically develop Haikou's resilience defense system from social, spatial, and temporal dimensions[3].

3.1 Social Dimension

The essence of constructing social resilience lies in coordinating the tripartite dialectical relationship among spatial

justice, human capital, and material foundations. First, from the perspective of spatial production theory, a resilient city needs to eliminate the locational deprivation effect in resource access through institutional design. This requires establishing a mechanism for equitable accessibility to medical and educational facilities, and implementing inclusive spatial policies to reduce the exposure risk of vulnerable groups. Second, structural changes caused by intergenerational replacement and population migration pose continuous challenges to a city's adaptability. In the context of an aging society, it is necessary to build age-friendly community living circles to enhance the risk resistance capabilities of physically vulnerable groups. Finally, the economic system forms the material foundation of a resilient city, which involves developing a diversified industrial ecology to avoid the risks of a single economic model, fostering a flexible job market to enhance crisis buffer capacity, and constructing a mechanism for the rapid reorganization of the value chain after disasters[4].

3.2 Spatial Dimension

From the perspective of complex system theory, spatial resilience manifests as five interacting subsystem clusters: the morphological organization system, engineering bearing system, life support system, ecological regulation system, and strategic node system. Through non-linear interaction mechanisms, the elements of each system form a spectrum of safety performance responses under different risk scenarios. Taking flood disasters as an example, the topological structure of engineering pipe networks and the density of green infrastructure networks together form a composite defense interface against flood peak impacts. The coupling effect of these spatial elements indicates that achieving a resilience leap through systematic spatial intervention has significant scientific value[5].

3.3 Temporal Dimension

3.3.1 Steady-State Operation Period

The steady-state operation period of an urban system has the dual attributes of normal operation and risk accumulation. During this stage, the planning system needs to rely on resilience baseline theory to construct a two-way verification model of historical disaster data and real-time monitoring data. By deploying a ubiquitous sensing network to integrate multi-source heterogeneous data streams, and combining it with a spatial decision support system, the status of key infrastructure can be evaluated.

3.3.2 Disaster Disturbance Period

During this stage, the core goal of resilience planning shifts to maintaining the basic threshold of urban metabolism. Based on complex adaptive system theory, a coupled model of "distributed decision-making architecture - cross-level response network" should be constructed: Reconstruction of the decision-making center: Adopt digital twin technology to achieve disaster situation awareness, and use multi-layer neural network algorithms to analyze the thermal distribution of human flow and the vulnerability map of lifeline systems. Dynamic resource adaptation: Establish a fault-tolerance mechanism for resilient infrastructure, and rely on blockchain smart contracts to realize decentralized scheduling of backup resources. Optimization of evacuation routes: Use reinforcement learning models to iteratively update escape routes in real time, balancing the dual constraints of rescue efficiency and secondary disaster avoidance.

3.3.3 Recovery and Reconstruction Period

Post-disaster recovery is essentially an adaptive reorganization process of complex social-technical systems. According to the "window of opportunity" theory, a three-stage intervention strategy should be implemented during this stage: Diagnosis of system vulnerability: Use social-ecological network analysis to identify multi-dimensional shortcomings in the physical environment, institutional structure, and cultural cognition. Optimization of structural performance: Embed resilience-enhancing designs in infrastructure restoration, such as integrating drainage pipe network reconstruction with sponge city modules. Transformation of development paradigm: Guide the iterative upgrading of disaster-affected areas toward innovative service functions through a toolkit of spatial redevelopment policies.

4. Governance Model

In the process of building Haikou into a resilient city, the government should establish an assessment and accountability mechanism for resilience performance, formulate benefit distribution rules for public-private partnerships, and maintain the credibility of the disaster prevention information platform. At the same time, design a "Community Resilience Partner" program to deeply integrate public participation into the entire planning process, thereby effectively addressing the problems of fragmentation and tokenism in traditional public participation.

5. Conclusion

The construction of a safe and resilient city is a crucial measure to ensure urban safety, and it is of great significance for enhancing a city's ability to respond to sudden risk impacts, creating a high-quality livable environment, and improving the quality of life. Based on an analysis of the research background, this study systematically sorts out the theoretical origin and international practice of safe and resilient cities, and puts forward ideas for building Haikou into a resilient city from the social, spatial, and temporal dimensions. It is suggested that future research focus on optimizing dynamic risk assessment models under climate change scenarios and analyzing the cost-benefit of resilience construction.

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