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Disaster Types and Resilience Evaluation in Guangzhou

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Abstract: The impact of natural disasters on urban areas had been profound throughout history, significantly affecting daily life and causing substantial economic losses, thereby impacting economic development. Therefore, was is important to fully understand and predict the types of natural disasters that will occur. At the same time, cities also need to be resilient in order to return to pre-disaster levels as much as possible in all aspects, while minimizing the impact of natural disasters. This paper delved into the various types of natural disasters resulting from climate change, focusing on case studies in Guangzhou. It conducted a comprehensive analysis of the potential impacts and hazards, dissecting the recovery capabilities of different regions in Guangzhou in terms of economic, social, ecological, and infrastructure aspects. This paper found that the resilience of various districts in Guangzhou was significantly different at different levels. The resilience of economy, society and infrastructure in the central urban area was higher than that in the urban fringe area due to the higher economic level, residents' education level and infrastructure perfection. The paper evaluated the effectiveness of various measures that had been taken to cope with natural disasters and identified the strengths and weaknesses of recovery in different regions. Additionally, it proposed strategies for enhancing the resilience of cities in dealing with disasters, particularly in the areas of social, infrastructure, risk assessment, and ecology, aiming to improve Guangzhou's resilience to natural disasters and provide feasible solutions. And this will improve the overall post-disaster resilience of Guangzhou and help achieve better recovery.

Keywords: Resilience, Natural disaster, Guangzhou.

1. Introduction

In today's world, the complexity of climate change had led to a growing impact of natural disasters on human societies. Understanding and addressing global environmental challenges was crucial through climate change research [1], which helped governments predict the frequency and intensity of extreme weather events, enabling more effective decision-making to minimize their impacts on human societies and ecosystems. Studies had shown that due to a lack of understanding of earthquakes, not only did they result in substantial material losses but also severely disrupted urban infrastructure and social order, with the number of earthquakes increasing annually [2]. Natural disasters also posed a threat to human health, most directly through casualties [3]. In China, an average of approximately 300 million people (occurrences) were affected by various natural disasters each year, with about 300,000 houses collapsing and 8 million people being temporarily relocated, a

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massive figure. Moreover, after natural disasters, disaster victims often experienced a decline in resistance due to environmental degradation, water pollution, scarcity of drinking water and food, and psychological trauma, leading to the outbreak of infectious diseases that significantly affected public health [4].

The concept of resilience, derived from the Latin term resilio, which means the action of jumping back, had been introduced into the field of ecology by Holling , treating it as the capacity of an ecosystem to remain unchanged while enduring alterations in quantity.[5]. Currently, it is a focal point in multiple disciplines including climate change, disasters, and more. In the study of resilience, Folk [6] had reviewed resilience as a valuable topic in a lot of academic areas, and it was a beneficial characteristic for both natural systems and humans, promoting sustainable development, and thus, it was worth in-depth study. The resilience of cities in dealing with disasters referred to their ability to effectively recover to their pre-disaster state or even higher levels after suffering from natural or human-induced disasters. This resilience encompassed not only the reconstruction of physical infrastructure, such as repairing roads, bridges, and buildings, but also involved comprehensive recovery in social, economic, and environmental aspects. This highlighted the need for the government to develop cross-sectoral recovery strategies, coordinating efforts across various domains [7]. Resilience manifested in multiple dimensions: firstly, the establishment of a rapid response mechanism to ensure swift organization of rescue and recovery efforts after disasters; secondly, the enhancement of community resilience, emphasizing the importance of disaster resilience in community response [8], which could help implement measures to reduce the impact of disasters on the community; thirdly, support from policies and urban planning, requiring the government to formulate scientific and reasonable post-disaster recovery plans to ensure the effective allocation of resources. In addition, restoration also included the restoration of the ecological environment. The second IHDP Update in 2003 had described the importance of ecosystem restoration in resource utilization, risk response, reducing vulnerability, and improving the integrity of future ecosystems [9].

Guangzhou, located in the southern part of China, was characterized by a subtropical monsoon climate with warm and humid conditions, distinct seasons, and abundant rainfall. Due to its diverse natural climate, Guangzhou frequently encountered various natural disasters. This paper would analyze the situation based on Guangzhou's disaster occurrences, evaluating the city's capability to cope with natural disasters.

2. Analysis of disaster situation in Guangzhou

Guangzhou, one of China's four major cities, played a significant role in the economy, driving the development of surrounding cities. Moreover, Guangzhou had boasted a well-developed transportation network, including Guangzhou Baiyun International Airport and Guangzhou South Railway Station, establishing it as a key aviation and railway transportation hub in southern China, contributing significantly to economic development. The types of disasters that Guangzhou frequently encountered included typhoons and geological disasters.

(1) During the summer months, Guangzhou was often affected by tropical cyclones and typhoons, leading to heavy rainfall, strong winds, and tsunamis. During the typhoon season, strong rainfall and winds caused floods, landslides, and road disruptions, significantly impacting daily life and property. Additionally, flooding disasters were common in Guangzhou due to its low-lying terrain and inadequate drainage systems, leading to frequent urban flooding and waterlogging in low-lying areas, causing inconvenience and losses in urban traffic and daily life. Furthermore, given its location near the Pearl River Delta, Guangzhou was prone to heavy rainfall, especially during the rainy season (typically from May to September), which could lead to floods, particularly in low-lying areas and river banks. Many roads were submerged, houses were destroyed, and people's homes were severely damaged. In many severe areas, the safety of people's lives was also threatened. Furthermore,

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Guangzhou was located along the coast of the South China Sea, frequently affected by typhoons. The strong winds brought by typhoons resulted in severe wind disasters, affecting transportation and infrastructure. The strong winds caused many billboards and plants to be blown over, resulting in significant damage to public facilities and impacting daily life. At the same time, typhoon disasters triggered heavy rainfall, especially in the summer, leading to urban flooding, traffic paralysis, and crop damage. Heavy rainfall caused some roads to be flooded, causing traffic congestion, making it difficult for vehicles to travel and affecting citizens' mobility. Heavy rainfall also caused the closure of shops and markets, affecting commercial activities and causing economic losses. At the same time, it caused agricultural losses: heavy rainfall led to flooded fields, affecting the growth and harvest of crops. Additionally, in the hilly areas, heavy rainfall often led to frequent geological disasters such as landslides and mudslides, posing a threat to the safety of residents and buildings.

(2) As a major city in southern China, Guangzhou faced various geological risks due to its complex geological conditions. Firstly, earthquakes, with Guangzhou located on the Pacific Ring of Fire, although with relatively low seismic activity, earthquakes still posed a risk. Historical records of earthquakes in Guangzhou indicated that these earthquakes could cause damage to buildings and infrastructure. Secondly, landslides and rock falls were frequent in the hilly areas of Guangzhou due to uneven geological structures and high rainfall, leading to landslides that could damage roads, farmland, and buildings, affecting residents' lives and production. In summary, these geological disasters had a significant impact on the lives of Guangzhou's people, even threatening their safety.

3. Resilience evaluation in Guangzhou

This paper analyzed and evaluated Guangzhou's resilience across four dimensions: economy, ecology, infrastructure, and society, based on the city's overall characteristics. Each dimension was assessed using specific indicators, and the overall resilience of Guangzhou was derived from these evaluations.

(1) Economic Evaluation: By examining Guangzhou's attributes over the past decade, this paper utilized the average annual comprehensive energy consumption as an indicator of economic stability. It gauged the richness of economic resources through per capita GDP, disaster prevention investment, and economic density over the past decade. The annual average value added of the tertiary industry was also considered to measure economic resilience. Through weighted calculations, the economic recovery index for each district was determined. Liu's research revealed significant spatial disparities: central areas > peripheral areas. Districts such as Tianhe, Huangpu, and Yuexiu showed higher economic recovery visibility, whereas districts like Chaohu and Zengcheng exhibited weaker economic recovery [10].

(2) Ecological Recovery Evaluation: This section analyzed the quality of Guangzhou's urban characteristics and its resilience against various disasters, including flood, meteorological, earthquake, and geological events. The paper assessed ecological resilience and carrying capacity using the combined comprehensive air quality index. The urban built-up area's ecological source area and green coverage rate were indicators for measuring ecological elasticity. Liu's research indicated that the overall ecological resilience of Guangzhou's districts was moderate, with districts in the southern and central areas (Baiyun, Zengcheng) and the eastern part of Chaozhou (Dongcha) performing relatively better. Ecological resilience was negatively correlated with proximity to the city center.

(3) Infrastructure Recovery Evaluation: After scrutinizing the distribution and current status of Guangzhou's infrastructure, the paper measured infrastructure resistance using the average daily water usage per person. The number of 5G base station facilities, the distribution of emergency shelters, and the distribution of medical institutions were used to gauge infrastructure adaptability. The total length of urban roads, the amount of demolished illegal construction buildings, and the number of large hospital beds were indicators for post-disaster infrastructure resilience. Liu's research showed significant regional differences in infrastructure recovery capabilities, generally at a moderate

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level, with districts like Baiyun, Huangpu, and Panyu demonstrating high recovery levels, while districts like Liwan and Haizhu showed low recovery levels [10].

(4) Social Recovery Evaluation: Focusing on Guangzhou, the paper analyzed the city's average annual population density (indicative of social resistance decline), urbanization rate, and structural characteristics to conduct a vulnerability analysis of vulnerable groups. It evaluated the adaptability of society and resource storage capacity using the past decade's average social security level and public safety investment. The annual average natural population growth rate and the number of college students over the past decade were used to measure social resilience. The paper's weighted calculations resulted in the social recovery index for each district. Liu's research indicated that social recovery capabilities tended to cluster around the city center, with districts like Tianhe, Yuexiu, Liwan, and Haizhu showing significantly higher social recovery capabilities, while peripheral areas exhibited lower levels [10]. Most districts had a moderate level of social recovery capability.

4. Strategies to improve the resilience of Guangzhou to cope with disasters

Based on the analysis presented in this paper, there are three primary approaches that can assist cities in augmenting their resilience against natural disasters:

(1) Undertaking risk evaluations and preemptive planning. Cities must conduct thorough natural disaster risk assessments to enable governmental decision-makers to predict potential disasters, pinpoint vulnerable areas and facilities, and gauge the potential extent of damage. This includes risks from floods (both coastal and flash), earthquakes, and even typhoons. The outcomes of these disaster assessments can serve as the bedrock for the government to formulate more comprehensive disaster preparedness strategies, encompassing measures such as fortifying infrastructure, enhancing public safety education, establishing emergency shelters at strategic intervals along transportation networks, stockpiling essential supplies, and improving communication networks to ensure the successful execution of rescue operations.

(2) Investing in infrastructure development and technological advancements. The sophistication of a city's infrastructure is the bedrock of its disaster resistance. Cities should allocate resources to strengthen infrastructure, including improving the seismic resilience of buildings, reinforcing water supply and drainage systems, and enhancing the power grid for reliability. Additionally, leveraging modern technology to augment disaster response capabilities: for instance, employing remote sensing technology for real-time monitoring of disaster occurrences, providing accurate geographic information, enabling rapid identification of affected areas. Utilizing big data analysis to amalgamate historical data with real-time information to forecast disaster trends and efficiently allocate resources. Crucially, the implementation of artificial intelligence, which can offer swift decision support in disaster response, automatically pinpoint damaged areas, and predict the movement of victims.

(3) Elevating community engagement. Communities are the first line of defense for cities confronting natural disasters, and bolstering community resilience is pivotal to enhancing disaster resilience. Firstly, education and training are indispensable. Regular disaster response knowledge instruction for local residents can enhance their self-rescue capabilities and mutual aid capacities. It is also crucial to encourage public participation in the creation and implementation of disaster response plans, fostering community awareness to expedite community response times.

Implementing these strategies in cities not only significantly reduces the direct losses incurred by natural disasters but also ensures the smooth functioning of disaster-impacted organizations, guarantees the safety and basic living security of residents, and promotes sustainable urban development.

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5. Conclusion

To evaluate Guangzhou's resilience to natural disasters, this paper analyzed the types of natural disasters that Guangzhou frequently encountered, including geological disasters and typhoons, and delved into their impacts on society and the ecosystem. At the same time, the paper evaluated the recovery capabilities of different regions in Guangzhou in terms of natural disasters, using various indicators to analyze the resilience of disaster recovery in different regions. The paper thus provided an overall assessment of Guangzhou's resilience to natural disasters. From the economic point of view, the resilience of the central area of Guangzhou was greater than that of the marginal area; From the ecological perspective, the ecological resilience of each district in Guangzhou was negatively correlated with the proximity of the city center. From the perspective of infrastructure, the overall infrastructure resilience of all districts in Guangzhou is at a medium level, and Baiyun, Huangpu and Panyu districts were relatively high. From a social point of view, the social resilience of central urban areas slightly exceeded the resilience of remote areas.

Furthermore, the paper proposed strategies for enhancing the resilience of cities in dealing with disasters, particularly in the areas of social, infrastructure, economics, and ecology, aiming to improve Guangzhou's resilience to natural disasters and provide feasible solutions. The first action was to conduct risk assessment and planning, providing early warning for potential natural disasters, and making preparations in terms of materials and facilities. Evacuation and recovery plans were also planned. Secondly, cities worked on strengthening the development and upgrading of infrastructure, aiming to improve reliability and also utilizing modern technology, data analysis, decision support, and thinking assistance. Finally, Guangzhou increased the community's participation in preventing natural disasters. Pre-disaster education was implemented, allowing people to enhance their self-rescue abilities and mutual awareness, thus better preparing them to face disasters when they occurred.

Due to the lack of specific meteorological data and internal planning schemes from the government, the paper could not provide a precise assessment of the disasters Guangzhou had experienced or fully evaluate the effectiveness of the government's measures against natural disasters.Future research was hoped to focus on the integration of smart cities and disaster resistance, developing a reliable and intelligent scheme to cope with the variability of natural disasters. Additionally, future research was expected to further analyze the patterns and causes of natural disasters, more accurately predict them, and provide a better disaster response plan, transforming Guangzhou into a sustainable city. The aim of this paper was to provide an analysis of potential natural disasters that coastal cities like Guangzhou might face, as well as corresponding strategies to enhance their resilience. Through the analysis of different regional resilience, a plan was provided to improve the resilience of cities in dealing with natural disasters.

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