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Research Article

Efficiency of Government Emergency Management for Typhoon Disasters in Zhoushan City, Zhejiang Province, People's Republic of China

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ABSTRACT

This article aimed 1) To analyze the strengths and limitations of current governmental emergency management mechanisms in responding to typhoon disasters in Zhoushan; 2) to assess the effectiveness of early warning systems and emergency resource allocation in typhoon disaster management in Zhoushan; and 3) to examine the operational challenges of inter-island and maritime emergency response during typhoon disasters in Zhoushan. The research was a qualitative approach. This research procedures were divided into three steps: Identifying the key variables related to emergency management performance, early warning systems, and resource allocation efficiency; examining the components of government coordination, public satisfaction, and system integration; and formulating strategic guidelines and policy recommendations to optimize emergency management practices in coastal cities such as Zhoushan. Data collection was conducted through in-depth interviews with 24 respondents, consisted 12 men and 12 women, aged 30-50 years old, all of whom were participants in the emergency management of typhoon disasters. The result of this research found that: 1) the current government emergency management mechanism in Zhoushan City had unique advantages in responding to typhoon disasters, but also had obvious limitations; 2) the clarified of the effective ways for government agencies to establish inter island warning systems and allocated emergency resources; and 3) the inter-island warning system and emergency resource allocation method established by government agencies could efficiently respond to typhoon disasters.

Keywords: Emergency Management, Typhoon, Disasters, Zhoushan City, People's Republic of China

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Introduction

Zhoushan City was located on the eastern coast of China and in the northeast of Zhejiang Province. It consists of 1390 islands and was an important island city in the Yangtze River Delta region. Its unique geographical location places it in a key area of the northwest Pacific typhoon path. Every summer, it was frequently hit by typhoons due to the influence of subtropical high pressure and monsoon circulation. As an important development area of China's marine economy, Zhoushan City in Zhejiang Province is affected by typhoons 3-5 times a year (Talley et al., 2008).

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With the intensification of global climate change, the economic losses caused by super typhoons such as Typhoon Meihua in 2022 have increased by an average of 12% annually (Chang & Falit-Baiamonte, 2002), exposing structural deficiencies in the existing emergency management system in early warning response, resource allocation, and post disaster reconstruction. In response to the above issues, it is urgent to establish a scientific and efficient emergency management mechanism for typhoon disasters. By integrating multi-source monitoring data and establishing a multi-scale simulation system for typhoon wind fields, the impact of typhoons of different intensities on island areas can be accurately predicted (Elsner & Jagger, 2023). Optimizing emergency management is not only related to the improvement of disaster prevention and mitigation capabilities in Zhoushan City, but also an inevitable requirement for ensuring the safety of national strategic material transportation channels and maintaining sustainable development of the marine economy (Hallegatte et al., 2019). It has important demonstration significance for exploring the modernization path of disaster management in coastal areas.

The current typhoon disaster prevention system still has significant shortcomings in early warning response, infrastructure resilience, and post disaster recovery mechanisms. In the process of typhoon defense, the weak links in government emergency management were mainly reflected in the lack of systematicity in the defense system, the mismatch between infrastructure design standards and extreme environments, and the insufficient refinement of risk control in key industries (Tierney, 2014). The lack of systematic defense system for typhoon disasters was a key issue in current emergency management. The existing defense measures mostly focused on emergency response during disasters, and the connection mechanism between pre disaster risk assessment and post disaster recovery and reconstruction was not yet perfect. Taking the defense against Typhoon Maria in 2018 as an example, although local governments had achieved certain results in emergency response and personnel transfer, there were still significant shortcomings in areas such as disaster chain risk assessment, cross departmental collaboration, and public awareness of disaster prevention, resulting in the failure to maximize defense effectiveness. This research focused on the optimization path of government emergency management for typhoon disasters in Zhoushan City, Zhejiang Province. The aim was to analyze the shortcomings of the existing system, propose a comprehensive solution covering risk assessment, infrastructure resilience improvement, industry precision control, and collaborative innovation of early warning response, and provided theoretical support and practical reference for improving the governance capacity of extreme weather disasters in island areas (Shi, 2019).

This article mainly adopted qualitative research methods. Through the mutual verification of interview communication and the integration of case analysis and empirical research, a comprehensive research framework suitable for emergency management of typhoon disasters in Zhoushan City was constructed. At the theoretical analysis level, relying on the disciplinary framework of disaster meteorology, this paper systematically sorted out the formation mechanism, evolution laws, and implications for emergency management of typhoon disasters, and establishes an emergency decision-making theoretical model based on the characteristics of meteorological disasters. At the same time, using risk model library technology to build a multi-dimensional data platform that included historical disaster situations, emergency resources, vulnerability assessments, etc., to provide visual decision support for emergency management (Goodchild & Glennon, 2010).

As the first prefecture level administrative region in China to establish a city based on islands, Zhoushan's research on typhoon disaster emergency management had unique theoretical value. This study filled the gap in the theoretical research on emergency management of island cities by analyzing the coupling mechanism between the geographical characteristics of Zhoushan Archipelago and typhoon disasters (Pelling & Uitto, 2001). The proposed "monitoring warning response recovery" full chain optimization model innovatively combines marine meteorological monitoring data with government emergency decision-making systems, providing a "Zhoushan sample" for disaster management theory. Especially the construction of a vertical monitoring system based on phased array radar and microwave radiometer had broken through the limitations of traditional planar monitoring and provided new ideas for the research and development of extreme weather warning technology (Wang, 2023). In addition, the introduction of the dual mechanism of "meteorological risk warning + maritime safety intelligent control" enriches the connotation of disaster collaborative governance theory and provided theoretical reference for other coastal cities to cope with complex disasters.

At the practical level, this article studies the current situation and problems of emergency management for typhoon disasters in Zhoushan, and proposes optimization paths with regional adaptability, including improving the fine construction of monitoring and early warning networks, building cross departmental collaborative emergency command systems, and strengthening disaster resilience at the community level. These strategies could not only provide scientific basis for disaster prevention and reduction in Zhoushan City, but also provided replicable experience paradigms for the construction of emergency management systems in typhoon prone coastal areas of China. In terms of social value, optimizing the emergency management system could effectively reduce the destructive impact of disasters on the economy. At the same time, by enhancing public disaster prevention awareness and self-rescue capabilities, a more resilient community environment could be built, laying the foundation for social stability. This article aimed to promote the establishment of a more dynamic and adaptable emergency response framework for typhoon disasters through systematic analysis, facilitate the transformation of disaster management from passive response to active prevention and control, and ultimately achieved the coordination and unity of disaster prevention and reduction with economic and social development.

Research Objectives

1. To analyze the strengths and limitations of current governmental emergency management mechanisms in responding to typhoon disasters in Zhoushan.

2. To assess the effectiveness of early warning systems and emergency resource allocation in typhoon disaster management in Zhoushan.

3). To examine the operational challenged of inter-island and maritime emergency response during typhoon disasters in Zhoushan. This research employed a qualitative research approach.

Research Methodology

This study employed a qualitative research approach. The research procedures were described as follows.

1. Key Informants

The population of this study consisted of stakeholders involved in typhoon disaster emergency management in Zhoushan City. The key informants included government officials, emergency management personnel, policy planners, logistics coordinators, community leaders, enterprise representatives, and local residents in high-risk coastal areas. A total of 24 key informants were selected using a purposive selection, based on their expertise, professional roles, and direct involvement in disaster management, early warning systems, emergency coordination, and community disaster response. These informants represented different sectors related to typhoon disaster management, including government agencies, research institutions, emergency rescue organizations, community organizations, and private sector representatives.

2. Research Instruments

The main research instrument was a structured interview guide with branching questions, designed in alignment with the three research objectives.

For Objective 1, the interview questions focused on governmental emergency management mechanisms, particularly inter-agency coordination and implementation of emergency plans.

For Objective 2, the questions examined the effectiveness of early warning systems and the processes of emergency resource allocation, including information dissemination and resource deployment.

For Objective 3, the interview guide addressed operational challenges in inter-island and maritime emergency response, including vessel management, maritime risks, and cross-regional coordination.

3. Data Collection

Data were collected through literature review, in-depth interviews, and participatory observation. Relevant government reports, academic studies, policy documents, and typhoon disaster cases were reviewed. In-depth interviews were conducted with the 24 key informants through face-to-face or online communication. Participatory observation was also carried out during activities related to typhoon disaster prevention and emergency response.

4. Data Analysis

The collected data were analyzed using qualitative methods, including content and thematic analysis. Interview transcripts, documents, and field notes were organized according to the disaster management stages of prevention, preparation, response, and recovery. Content analysis was used to compare and interpret patterns across different data sources, while thematic analysis involved coding the data, grouping similar codes into categories, and developing key themes related to emergency management, early warning systems, and inter-agency coordination. Triangulation was applied to enhance the credibility of the findings.

Conceptual Framework

This conceptual framework was synthesized from prior studies on typhoon disaster management, early warning systems, governance coordination, public participation, technological support, and cross-regional cooperation. The framework was primarily informed by Huang et al. (2025), Kongthon et al. (2014), Yu et al. (2022), Fan (2025), Wang (2023), Zhou et al. (2022), and Zhou et al. (2025).

Research Results

Based on the findings, the study revealed the following results:

1. To analyze the strengths and limitations of the governmental emergency management mechanisms.

The findings indicated that Zhoushan City had established a relatively comprehensive typhoon disaster emergency management system. The "1833" jointed command system forms an emergency response framework with the municipal defense headquarters as the core and was supported by multiple specialized command posts, which enhanced coordination among departments and enabled efficient emergency decision-making. In addition, Zhoushan had developed a comprehensive contingency plan system for disasters such as flood control, drought prevention, and typhoon preparedness. These plans were updated regularly based on changes in typhoon patterns, disaster management experience, and urban development, providing a strong institutional foundation for emergency management. Furthermore, the standardization of grassroots flood and typhoon prevention systems had strengthened local disaster preparedness and response capacity. Through the establishment of township and village-level responsibility systems, emergency response teams, and disaster prevention mechanisms, grassroots emergency management capabilities had been significantly improved. However, the study also identified several limitations in the existing emergency management mechanisms. In particular, social coordination mechanisms still require improvement, as channels for public participation remain limited and coordination among social organizations and volunteers during emergency response operations was not sufficiently unified. As evidenced by interview data, As Key Informant noted, "the command system operated efficiently, with various departments coordinating seamlessly; early warning information could be quickly disseminated, and grassroots grid workers took prompt action to relocate residents in advance." Similarly, Key Informant 23 highlighted that "early warning information was conveyed immediately, and grid workers swiftly took action to investigate potential hazards and notified households to evacuate." In addition, Key Informant 21 emphasized that "the government provided accurate early warnings in advance, giving enough time to recall fishing boats and reinforce aquaculture facilities."

2. To assess the effectiveness of early warning systems and emergency resource allocation in typhoon disaster management in Zhoushan.

The results showed that Zhoushan City had established a relatively comprehensive early warning and monitoring system. By integrating satellite data, coastal radar, drone patrols, and smart sensors, the city was able to monitor typhoon trajectories, intensity, and potential impacts in real time. The meteorological department had continuously improved forecast accuracy and warning lead time, providing important scientific support for emergency decision-making. As stated by Key Informant 1, "we should integrate data from multiple departments such as meteorology and oceanography to enhance

monitoring accuracy and deliver early warnings precisely to different regions and groups of people." In addition, Key Informant 7 emphasized that "multi-source data such as satellite, radar, and buoys should be integrated, and AI technology should be applied to improve the accuracy of typhoon path and intensity forecasting." Moreover, Zhoushan City had established an emergency material reserve system that included equipment such as drainage pump trucks, assault boats, rubber boats, generators, water pumps, and emergency lighting equipment. The city had also strengthened the construction of professional emergency rescue teams and established comprehensive emergency response teams across all townships and subdistricts. These resources provided important support for typhoon disaster response. From the community perspective, Key Informant 19 stated that "village loudspeakers, text messages, and WeChat groups should be used to ensure warnings reach everyone, and training should be provided so that people knew how to respond properly when warnings were issued." Nevertheless, the study found that the precision of emergency resource allocation still needs improvement. In practice, problems such as information asymmetry and delayed deployment of emergency materials might occur, particularly when multiple areas were simultaneously affected by disasters, which might reduce the efficiency of emergency response.

3. To examine the operational challenges of inter-island and maritime emergency response during typhoon disasters in Zhoushan. This research employed a qualitative research approach.

As an island city with geographically dispersed communities and frequent maritime activities, Zhoushan faces unique challenges in typhoon disaster emergency management. The study found that the city had strengthened coordination among different departments and regions through the joint command system and cross-regional emergency cooperation mechanisms. These mechanisms helped improve information sharing, resource coordination, and joint response capacity during typhoon disasters. However, several challenges remained in the management of maritime and island-based emergency responses. The complex maritime environment and diverse types of vessels increased the difficulty of emergency management during typhoons. Although Zhoushan had formulated maritime typhoon prevention guidelines and established specialized rescue teams, practical operations still face problems such as non-standard vessel management and limited maritime rescue capacity. These challenges indicated that further improvements were needed in maritime risk management and emergency rescue capabilities to enhance the effectiveness of typhoon disaster emergency management in island regions. As stated by Key Informant 4, "I suggested establishing a joint command framework involving multiple parties such as maritime affairs, fishery administration, emergency response, and rescued teams, to clarify responsibilities and improved coordination efficiency in maritime rescue." Meanwhile, Key Informant 6 stated that "I suggested establishing a joint emergency command structure and a unified information-sharing platform to enable real-time exchange of distress information and enhance maritime emergency response efficiency." These challenges indicated that further improvements were needed in maritime risk management and emergency rescue capabilities to enhance the effectiveness of typhoon disaster emergency management in island regions.

Discussions

1. Strengths and limitations of the governmental emergency management mechanisms.

The findings demonstrated that Zhoushan City had developed a relatively mature emergency management system for typhoon disaster response. The “1833” joint command system played a central role in coordinating multiple departments and improving the efficiency of emergency response operations. By integrating specialized command posts and establishing a unified command structure, the system enables rapid information sharing and coordinated decision-making during typhoon disasters. This finding was consistent with Zhang et al. (2023), who emphasized that standardized incident command systems significantly enhanced cross-agency coordination and reduced evacuation time in multi-hazard disaster contexts. In addition, the successful evacuation of 18,979 residents during the response to Typhoon “Bamboo Knot,” without casualties. This aligned with Suvanachai et al. (2025), who found that IoT-based monitoring systems in coastal disaster-prone areas improved early detection and significantly reduced response delays, enabling timely evacuation of at-risk populations. Moreover, the contingency plan system and standardized grassroots flood and typhoon prevention system provide strong institutional support for emergency management. This was supported by Wang (2023), who reported that community-based grid management systems enhanced disaster response efficiency and reduced casualty rates through improved local coordination mechanisms. However, the study also identified limitations in the existing emergency management mechanisms. In particular, social coordination mechanisms still require improvement. Although volunteer teams, enterprises, and social organizations had participated in emergency response activities, the lack of unified coordination might lead to inefficient resource utilization and reduced operational efficiency. Strengthening coordination among government agencies, social organizations, and enterprises was therefore necessary to further improve emergency management capacity.

2. Assess the effectiveness of early warning systems and emergency resource allocation in typhoon disaster management in Zhoushan.

The findings indicated that Zhoushan’s early warning system played a critical role in enhancing disaster preparedness, particularly through the integration of multi-source meteorological data, which enabled timely warning dissemination and supported emergency decision-making. This was consistent with Zhou et al. (2025), who emphasized that timely warning systems were essential in mitigating the impacts of extreme typhoon events, especially when disaster preparedness was insufficient. In addition, the application of advanced technologies in early warning aligns with Huang et al. (2025), who demonstrated that GIS-based dynamic risk assessment models could accurately identify high-risk areas up to 72 hours in advance, thereby improving preparedness capacity. However, despite the effectiveness of the early warning system, this study found that challenged remain in emergency resource allocation, particularly in terms of information asymmetry and delayed in material deployment during large-scale disasters. This limitation corresponded with the findings of Pal et al. (2022), which indicated that although multi-source data integration could significantly improve resource scheduling accuracy, inefficiencies might still occur due to delays in grassroots data updating and coordination gaps among departments. Therefore, further strengthening the integration of digital technologies and real-time data sharing mechanisms were essential to enhance both the precision and efficiency of emergency resource management.

3. examine the operational challenges of inter-island and maritime emergency response during typhoon disasters in Zhoushan. This research employed a qualitative research approach.

As an archipelagic coastal city, Zhoushan must manage typhoon disasters across multiple islands and maritime areas. The joint command system and cross-regional coordination mechanisms helped strengthen cooperation among different departments and regions, enabling the government to coordinate emergency responses more effectively during typhoon disasters. Nevertheless, the study indicated that maritime emergency management remained a complex challenge. The presence of fishing vessels, construction ships, and other maritime operations increased the risks associated with typhoon disasters. Although Zhoushan had established maritime typhoon prevention guidelines and specialized rescue teams, problems such as insufficient rescue equipment, limited manpower, and difficulties in vessel management might still affect emergency response effectiveness. Therefore, improving maritime risk management, strengthening maritime emergency rescue capabilities, and enhancing coordination with neighboring regions are essential for further improving the efficiency of typhoon disaster emergency management in Zhoushan's island regions. This was consistent with findings from Zhou et al. (2025), which highlighted that extreme typhoon impacted often trigger secondary disasters and exposed gaps in preparedness in coastal regions, particularly where infrastructure and operational readiness were uneven. Similarly, Sun et al. (2024) found that integrating traditional coastal infrastructure with modern emergency systems could reduce disaster-related damage by up to 45%, but implementation gaps remain, especially in complex coastal environments. In addition, Wuthisuthimethawee et al. (2022) demonstrated that regional coordination mechanisms across multiple countries could reduce response delays by improving real-time data sharing and maritime coordination efficiency, which directly corresponds to the cross-regional and maritime coordination challenges identified in this study.

Originality and Body of Knowledge

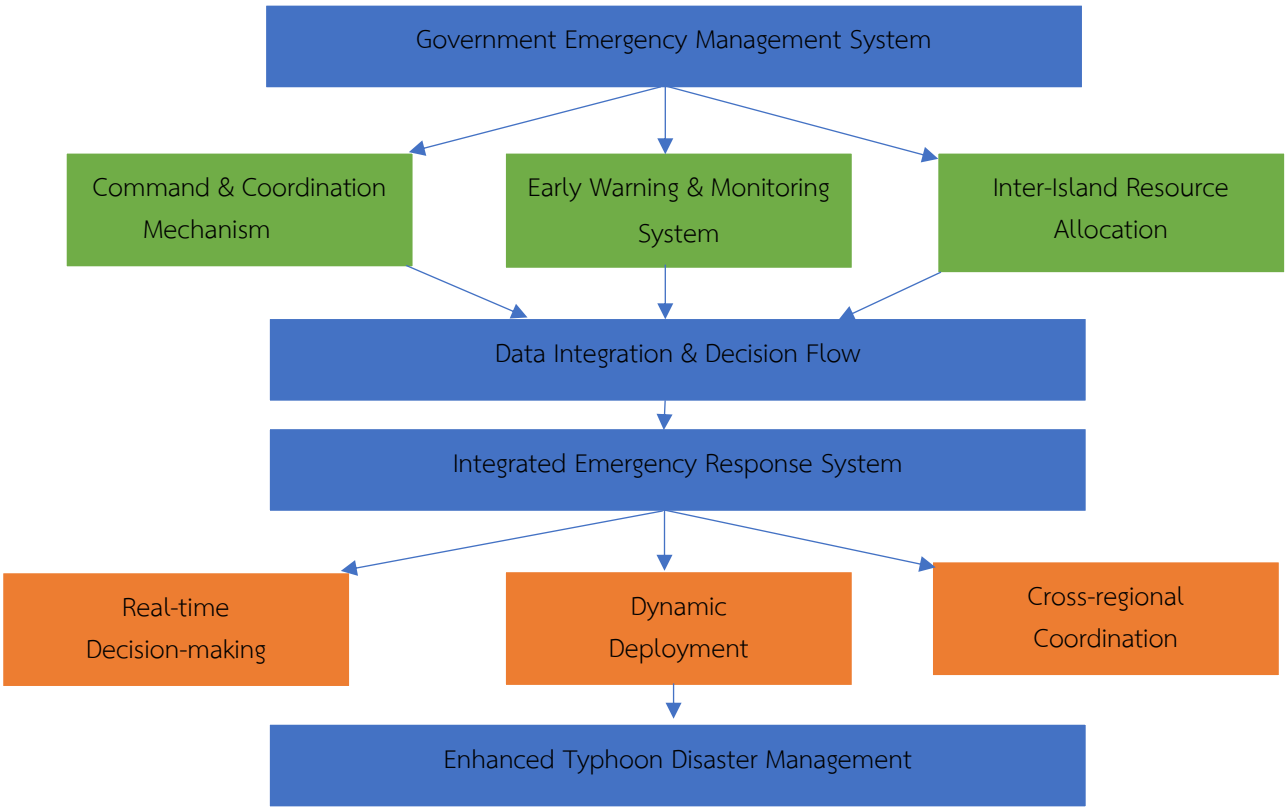


Figure 1 Typhoon Disaster Emergency Management in Zhoushan City

The new knowledge generated from this study indicated that efficient emergency management for typhoon disasters in Zhoushan City required the integration of three key mechanisms:

Command and Coordination Mechanism - the governmental command and coordination system, such as the "1833" joint command system.

Early Warning and Monitoring System - a technology-supported early warning and monitoring system, including satellite data, coastal radar, drones, and smart sensors.

Inter-Island Resource Allocation - mechanisms for the allocation of emergency resources among islands and across regions.

When these three components operated in an integrated manner, they form an Integrated Emergency Response, which enhanced the efficiency of typhoon disaster management in island areas.

Conclusions

The findings of this study could be summarized according to the research objectives. First, Zhoushan City had established a relatively comprehensive typhoon disaster emergency management system. The "1833" joint command system, contingency plans, and standardized grassroots prevention mechanisms enhance coordination and strengthen local disaster response capacity. However, limitations remained in social coordination and public participation. Second, Zhoushan had developed an integrated early warning and monitoring system supported by multiple technologies, along with emergency material reserved and professional rescue teams. These systems provided strong support for disaster response,

although challenges remained in the precision and timeliness of emergency resource allocation. Third, inter-island emergency coordination mechanisms helped improve information sharing and joint responses among different regions. Nevertheless, the complex maritime environment and diverse vessel activities continue to pose challenges for maritime emergency management and rescue capacity in island areas.

Recommendations

1. Policymaking Recommendations

1.1 The government should improve the emergency command and coordination mechanism by refining the operation of the “1833” Joint Command System and strengthening information sharing between grassroots units and higher-level authorities. Cross-regional cooperation with neighboring cities should also be enhanced to improve coordinated responses to typhoon disasters.

1.2 The government should optimize the distribution and management of emergency material reserves, strengthen the professional capacity and coordination of rescue teams, and utilize digital technologies such as big data and artificial intelligence to support the precise allocation of emergency resources during typhoon disasters.

1.3 It was recommended to enhance meteorological forecasting and early warning technologies, promoted the application of big data and IoT in emergency management, and improved maritime safety management and rescue capabilities to ensure effective typhoon disaster prevention and response.

2. Recommendations for Future Research

2.1 Future studies should develop comprehensive typhoon disaster risk assessment models by integrating meteorological, geographical, socio-economic, and environmental factors, and improved prediction accuracy through advanced technologies such as artificial intelligence and machine learning.

2.2 Future research should examine public psychological responses and behavioral patterns during typhoon disasters, and explored efficiency organizational and management models for emergency volunteer teams to enhance community participation in disaster response.

2.3 Future studies should evaluate the efficiency of existing emergency management policies and regulations and explore international cooperation and knowledge exchange to improve typhoon disaster management practices.

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