Development and Optimization of Emergency Management Information Systems: A comparative analysis of China, United States and Japan

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Abstract. With the rapid progress of information technology, information systems have come into being, and various industries have adopted them to optimize and process business information. And for the government, the importance of enhancing emergency response capability through information systems is self-evident. In recent years, the government has been paying more and more attention to emergency management, how to build an efficient and reliable emergency management information system has become a key issue that emergency managers need to solve, especially in the period of the new crown epidemic, an efficient and reasonable emergency management information system is particularly important. Therefore, based on the current Chinese and foreign literature about emergency management information systems, this study first defines emergency management information systems, summarizes the overall emergency management information system frame-work of China, the United States, and Japan, and then compares its characteristics and points out the shortcomings of China's current emergency management information system at the end of this study.

1 Introduction

With the process of globalization and urbanization, information technology has been an important force driving social development at present. Globally, natural disasters, public health events, and other emergencies and disasters occur frequently in the context. The importance of emergency management work has become more prominent, and governments have attached great importance to improving the level of emergency management and traditional emergency management in the exchange of data and sharing of information, and other aspects of the serious deficiencies, which led to an emergency The sharing of data, information, and knowledge for decision-making is difficult, and to break down these barriers and realize emergency management synergy and interconnection and interoperability, it is necessary to build a new generation of emergency management information system with huge data support, which can realize comprehensive sensing, dynamic monitoring, intelligent early

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warning, rapid disposal, and precise supervision [1].

On December 28, 2022, the Central Party School released The 2022 United Nations E-government Survey Report, and the report shows that China's e-government rankings compared to 2012 have improved significantly and risen to 43rd, which proves that China's e-government in recent years level of development of the rapid, but likewise, the current rankings also illustrate that the Chinese government in the e-government still has some room for improvement.

Emergency management information systems, as the focus of improving the level of emergency management, have become a hotspot of Chinese and foreign research on information systems in recent years in the context of the global impact of epidemics. Through extensive reading of these studies, thsi study found that in the United States and Japan, the emergency management information system research is more in-depth, its application is also more extensive, and in the United Nations report in 2022, the two countries of the e-government rankings are also located in the top 15, so this paper intends to be from the United States and the United States of America and Japan's emergency management information system research in the two countries at the moment. Therefore, this paper intends to start with the research of emergency management information systems in China, the United States, and Japan to compare the general framework of emergency management systems of the three countries to provide certain progress for the country in this area.

2 Definitions of emergency management information systems

2.1 Data sources and structure

There are usually four sources of data in an emergency management information system: the emergency management department, other governmental commissions and departments, the social side (enterprises, the public), and other sources of information [2]. The database table in the emergency management system has three main databases, which are Basic information base, geographic database, and knowledge base. The fundamental information database includes a data dictionary, emergency resource details, hazardous source information, and essential emergency data. The geographic database contains specialized geographic data and basic geographic data. The knowledge base contains expert knowledge, knowledge rules, and accident cases.

2.2 System architectures

The overall structure of the Emergency Management Information System (EMIS) is divided according to time: the prevention phase, the preparedness phase, the response phase, and the recovery phase [3].

The prevention phase contains a geographic information system (GIS), a visualization and monitoring subsystem, a hazard source management subsystem, a disaster assessment subsystem, an emergency response capability assessment subsystem, a safety education and training subsystem, and a safety planning subsystem.

The preparation stage contains an emergency resource management subsystem, an emergency plan management subsystem, a virtual emergency exercise subsystem, an expert management subsystem, and a hazard source monitoring subsystem.

The response phase contains an alarm receiving and dispatching subsystem, a digital recording subsystem, an on-site data transmission subsystem, an on-site gas monitoring and analyzing subsystem, an emergency resource dispatching subsystem, an evacuation of people, a simulation subsystem, a disaster relief resource management subsystem, an accident consequence simulation subsystem, and a disaster notification subsystem.

The recovery phase consists of an incident case management subsystem, an affected

household management subsystem, and a recovery planning management subsystem.

2.3 Functional divisions

Functions of an Emergency Management Information System (EMIS) corresponding to its structure: Prevention, Preparedness, Response, and Recovery.

Central to prevention is the use of hazard analysis to analyze and assess potential risks. This process requires close collaboration between local government agencies to address potential threats through efficient coordination and communication.

During the preparedness stage, the Government has significantly strengthened its emergency response capacity through the provision of technical support, professional training, preparedness plans, and practical exercises. These initiatives not only helped to quickly mitigate the impact of the disaster when it occurred but also ensured that it was able to quickly respond to all types of needs in the aftermath of the disaster, laying a solid foundation for effective recovery efforts.

Response work, on the other hand, focuses on ensuring the rapid activation and efficient implementation of emergency relief operations to minimize disaster damage and guarantee the basic survival needs of the affected population through the provision of basic livelihood assistance, including safe drinking water, food, shelter, and so on.

Recovery efforts, on the other hand, focus on assisting in large-scale infrastructure rehabilitation, especially the reconstruction and restoration of critical urban lifeline systems (e.g., transportation, communications, water supply, power supply, health care, etc.), this is of great significance in promoting rapid economic recovery and maintaining social stability.

3 Emergency management information system applications in China, U.S., and Japan

3.1 China's National System

At the beginning of the founding of New China, the disaster prevention and mitigation departments are independently responsible for the jurisdiction of the rescue and relief. In 1986, the Guangzhou Municipal Public Security Bureau set up China's first 110 alarm service station, in the following ten years, the construction of the 110 alarm service system was then extended out of the 119 and other special service codes. 1999, the 911 emergency response system is the first of its kind in China. Premier Zhu Rongji, during his visit to the United States, was invited to visit the 911 center in Chicago and later proposed that the 911 emergency response system is a symbol of the modernization of a city, China should strive to build its emergency linkage system. A similar emergency response system was first introduced in 2002 in Nanning, Guangxi, and was popularized nationwide after the 2003 SARS epidemic. As of December 2008, China's public security system based on the "three stations in one" emergency response platform is completed.

China's current emergency response platform system adopts a layered architecture, with the national-level emergency response platform at the top and extending downward to the provincial level, the municipal level, the county level, and the government departmental emergency response platforms at all levels. The national-level system is constructed and maintained by the central emergency management department, while the local-level system is maintained by the emergency management department of each local government. This structure ensures information sharing, command and coordination, and rapid response among emergency management departments at all levels, from the central to local levels. China's current architecture is designed to effectively respond to emergencies through monitoring and control, forecasting and early warning, rapid reporting of information, and comprehensive research. Research Judgment, auxiliary decision-making, and efficient

command and control functions to meet the needs of national and local government departments at all levels of emergency management.

During the Twelfth Five-Year Plan cycle, national-level emergency response platforms have been successfully constructed and put into operation, while most provincial-level platforms are accelerating in the construction process, with some provinces having completed their construction and put them into operation. Completed the construction and put it into use, in addition, the emergency platforms of several government departments have been physically deployed. At present, municipal and county governments are focusing their efforts on developing and applying integrated emergency management systems, which are regarded as key initiatives to strengthen the emergency management capacity of grassroots governments, and their importance and urgency are becoming more and more prominent. Adhering to the emergency management concept of "adequate preparation in normal times and rapid response in times of emergency," the integrated system is regarded as the cornerstone and core driving force for the construction of an efficient emergency management system.

3.2 The U.S. Emergency Management Information System

The United States federal government, through the Emergency Support Functional Annexes (ESFs) of the National Emergency Response Plan (NERP), defines in detail the arrangements between the federal government agencies and the Red Cross in terms of the deployment of resources, implementation of policies, organizational structure and division of responsibilities. Each functional annex designates the corresponding federal government coordinating agency, lead agency, and supporting agencies [4]. Among them, the coordinating agency undertakes preliminary planning tasks, maintains close communication with the lead agency and supporting agencies, and convenes regular coordination meetings with the functional stakeholders. The lead agency, as the core implementer, is responsible for manpower deployment and strives to ensure the adequacy of emergency resources. The auxiliary organizations, on the other hand, provide a full range of support, including manpower, equipment, technology, and information, according to the needs of the lead organization.

The activation of these functional annexes is based on the specific nature and needs of the incident, and once activated, the coordinating, lead, and supporting agencies will dispatch emergency response personnel or teams to seamlessly integrate into the overall Incident Command System structure and work together to respond to the emergency, according to their respective emergency support roles.

The U.S. Federal Emergency Management Agency (FEMA) has adopted and implemented the “e-FEMA” strategy, which builds a hierarchical architectural model for emergency information systems. This model aims to ensure that the data resources of various emergency information systems can be kept up-to-date in real-time and, at the same time, promote information interoperability and resource sharing among different systems to provide strong technical support for the emergency decision-making process [5]. Currently, the three major information systems widely used in the United States are as follows.

3.2.1 Federal Emergency Management Information System (FEMIS).

This system serves as a comprehensive decision-support platform that comprehensively covers the four key phases of emergency management: preparation, response, and recovery. It is mainly used to manage the core affairs of the emergency management process, such as plan making, coordination and communication, rapid response, professional training, and simulation exercises, and providing comprehensive support for emergency management.

3.2.2 Web Emergency Management System (Web EOC).

This system is designed for city-level emergency response, with functions covering incident management, emergency command and dispatch, resource optimization, and document management. Through Web EOC, the city's emergency management department can organize rescue operations more efficiently, optimize resource allocation, and achieve full tracking and recording of emergency events.

3.2.3 Disaster Damage Assessment System (HAZUS).

HAZUS system focuses on accurate prediction of damage that may be caused by natural disasters (e.g., earthquakes, floods, hurricanes, etc.) and proposes corresponding emergency strategies and mitigation measures, damage caused by natural disasters (e.g., earthquakes, floods, hurricanes, etc.), and proposes appropriate emergency response strategies and mitigation measures accordingly. By strengthening the management and assessment of buildings and other infrastructure, the system seeks to be fully prepared before a disaster occurs to minimize casualties and property damage and to protect public safety.

3.3 Japanese emergency management information system

To effectively respond to sudden-onset major disasters, the Government of Japan has constructed a disaster information integration system in which multiple actors work together [6]. The system not only promotes the integration and sharing of disaster information across sectors but also further promotes close interaction between the national and local governments and civil society organizations, realizing a shift from a single-level to a tripartite governance model that involves the collaboration of the national, local and civil sectors in a joint effort to comprehensively integrate and effectively respond to disaster information [7].

The emergency management information system currently applied in Japan is the SIP4D system.

Based on reflections on the response to the 2016 Kumamoto Earthquake, the Central Disaster Prevention Conference of Japan has recognized that the potential of information and communications technology (ICT) in the field of disaster management has not yet been fully realized. As a result, the conference decided to strengthen data sharing across national and local governments and private companies, and in April 2017, established the "Joint Disaster Information Governance Center" with the Cabinet Secretary for Disaster Prevention at its core, which brings together social organizations including the Keidanren and the Japan Gas Association, as well as Hitachi, Nippon Telegraph and Telephone, Nippon Freight Railway, and others. The center brings together several organizations, including the Japan Federation of Economic Organizations, the Japan Gas Association, and industry giants such as Hitachi, Nippon Telegraph and Telephone, and Japan Cargo Railways.

The main task of the center is to build a disaster information center for multiple subjects, such as administrative departments, enterprises, and disaster-affected people, based on the SIP4D platform to strengthen the support capacity for large-scale disasters. The biggest highlight of the SIP4D Disaster Information Center lies in the high efficiency of its information transmission and the flexibility of its modularization, which is specifically embodied in the three aspects [8].

3.3.1 Instant Information Sharing.

After a disaster, SIP4D can quickly gather and release relief information, such as the affected situation and the location of shelters, to ensure the safety of residents. SIP4D integrates disaster data from central ministries and commissions, local governments, and civic

organizations, and then the Disaster Information Support Teams go to the site to collect first-hand information and communicate this information to the government, enterprises, and the public through the Disaster Electronic Map Portal (NIED-CRS) in a visual way to improve the overall response efficiency. Through the NIED-CRS portal, this information is communicated in an intuitive way to the government, businesses, and the public to improve overall response efficiency.

3.3.2 Assisting local governments in emergency response.

SIP4D provides a series of customized business modules, such as the release of evacuation information, guidance for evacuation of residents, the establishment of emergency headquarters, the operation of shelters and road control, etc. SIP4D can also help local governments quickly build a disaster response system so that even non-professional disaster management personnel can rely on the platform to carry out their work effectively.

3.3.3 One-stop information dissemination.

SIP4D can centralize and integrate disaster information originally dispersed in various public information platforms, social media, and official government websites to achieve one-stop dissemination. At the same time, the platform supports the online generation of standardized disaster broadcast newsletters and instant delivery of these newsletters to relevant departments to achieve efficient and unified management of both supply and demand of information.

4 Problems analysis

4.1 Misconceptions about building systems in some areas

For the construction of emergency management information systems in some areas, there is a misconception that emergency management information systems are reduced to call centers, i.e., they are viewed as multi-departmental interconnected customer service centers. However, this understanding ignores the complexity and uniqueness of emergency management information systems. Emergency management information systems are not purely customer-centered; their core focus is on the efficient management of public emergencies [9]. In the time dimension, it requires a high degree of accuracy, even to the extent of “seconds” as the unit of refined time management.

The workflow of an emergency management information system is fundamentally different from that of a conventional e-government system. The workflow of conventional e-government systems is often flexibly adjusted according to the needs of the target audience, and the process is relatively simplified. In contrast, the process of an emergency management information system is more complex and rigorous, covering the rapid establishment of emergency communications, data-based analysis of the emergency, the development of emergency decision-making, efficient emergency command and control, timely implementation of emergency relief, as well as the entire incident from the investigation and assessment to the post-crisis recovery and reconstruction of the overall management [10]. This series of processes is not only interlinked but also contains more detailed sub-processes within each major link to ensure the comprehensiveness and effectiveness of emergency management.

4.2 Improper construction of the legal system

When confronted with emergencies, China still lacks the support of a sound legal system,

owing to the relatively short history of the construction and application of emergency management information systems. Although the release of the Overall Emergency Response Plan for Public Emergencies marks the initial establishment of China's emergency response plan framework system, China still lacks a unified legal system for emergencies compared with many developed countries and some developing countries around the world. This legal gap not only limits the ability to respond effectively to emergencies but also affects the long-term development of the emergency management information system, for which no solid legal guarantee can be provided.

4.3 Poor linkages between systems

China's informatization of emergency management is still in its infancy, with limited time to accumulate, which has led to a lack of unified technical standards and coordination mechanisms for local governments in the construction process [11]. The technology and facilities vary from place to place and are difficult to be compatible with each other, which in turn hinders the effective linkage between systems. Especially when dealing with large-scale emergencies across regions, the government has difficulty in quickly unifying the command and effectively scheduling various departments, which affects the timeliness and efficiency of the emergency response.

In addition, the platforms within the emergency management information system are not fully linked, and the system's functions are limited. The lack of clarity in authority and responsibility between departments has further weakened the overall connectivity of the emergency management system and created the phenomenon of "information islands". The lack of synergy in information acquisition, coordination, and communication in response to public emergencies has seriously reduced the crisis management efficiency of government departments.

5 Conclusion

This study reveals the characteristics and differences in the construction of emergency management systems in China, the United States, and Japan through a comparative study of their emergency management information systems. China's emergency management information system has made remarkable progress in recent years, especially in the construction of national-level platforms. However, compared with the United States and Japan, China still has many challenges in terms of the system's legal framework, information-sharing mechanisms, and multisectoral collaboration. The U.S. system has a more mature division of labor and coordination mechanism, while Japan relies on an efficient information-sharing platform that fully integrates the resources of government, enterprises, and social organizations. To further improve the level of emergency management in China, there is an urgent need to strengthen legal protection, promote system interconnection, and improve technical standards to build a more efficient and flexible emergency management information system to cope with increasingly complex emergencies.

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