Research on Collaborative Decision-making Mechanism of Emergency Management Departments in Major Emergencies Empowered by Digital Technology

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Abstract. In today's society, the development of digital technology in China is very rapid, and nowadays all kinds of major emergencies are also endless. All types of emergencies pose significant challenges and threats to our social stability, the peaceful lives of people, and national security. Digital technology is a fundamental technology for the advancement of modern emergency management. It serves as a crucial technical support for the establishment of emergency management systems and the prevention of emergencies in the new era. Therefore, conducting research on decision-making in emergency management for major emergencies, empowered by digital technology, is of great significance. First of all, this paper launched a study of major natural disasters, a specific scene of emergencies, for major natural disasters to carry out a whole process, the whole cycle of an analysis, and then on this basis for the development of the actual major natural disasters, emergency rescue research, emergency rescue for major natural disasters, material scheduling of supply and demand matching and the corresponding decision-making problems and The structure of supply and demand matching is analysed in depth. Next, the functional hierarchy of departmental coordination in emergency management is divided by introducing the target cascade idea of system engineering, and the corresponding departments of China's emergency management are divided according to their functions and roles in the response to emergencies, which are divided into three hierarchical architectures in the article, and the realisation of departmental coordination in emergency management is illustrated by combining this architecture with the idea of target cascade (ATC). The article concludes with future research priorities and outlooks, and puts forward corresponding recommendations.

Keywords: Big data; blockchain; collaborative sectoral decision-making; emergency management decision-making; hypercyclic theory; full emergency management cycle

1 Introduction

In the face of the current ever-changing world, there are all kinds of security risks hidden in all corners of the world, and all kinds of unconventional emergencies may occur at any time, posing great security risks to human society. In this context, China in order to better respond to all kinds of unconventional emergencies, in the pursuit of national stability, social stability, people's happiness under the purpose, China in 2014 put forward the overall national security concept[1] , in the report of the twentieth Party Congress, the report clearly pointed out the

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need to "establish a large security emergency response framework, improve the public security system, and promote the public security governance mode to the [2] , in the context of the policy and the overall national security concept, in order to enhance China's ability to respond to all types of emergencies, China urgently needs to establish a set of effective emergency management system that can respond to all types of major emergencies.

2 Literature review

2.1 Digital technology emergency management

In the context of the new era, digital intelligence technology (blockchain, big data, 5G, etc.) for the construction of China's emergency management system to a large extent, we can make full use of the characteristics of blockchain and other digital intelligence technology (blockchain three kinds of chain: public chain, private chain, alliance chain), and combined with the country's emergency management system to carry out a combination of the technical level and the institutional level, in order to achieve the efficient and collaborative work of the state departments, and improve the efficiency of inter-departmental collaboration, and thus improve the efficiency of China's emergency management work in response to various emergencies. A number of scholars have researched the development of digital intelligence technology for emergency management in China, for example, Azbeg[3] et al. published a review, in which they grouped different healthcare applications integrating IoT and blockchain in their system, and investigated the use of IoT and blockchain in healthcare IoT-based systems. The integration of digital technologies is crucial in addressing the challenges associated with the adoption of blockchain technology in IoT-based healthcare systems. Major public health emergencies, like the global COVID-19 pandemic, pose a significant threat to people's lives, health, and safety. Therefore, it is essential to develop effective solutions to cope with these outbreaks and control their spread. Improving emergency management capabilities in global public health emergencies is necessary, and the integration of digital technologies plays a vital role in achieving this goal. Wen[4] et al. have provided unique insights into the role of digital technologies in public health emergency management. Emergencies, due to their suddenness, hazardousness and coupling, often bring security risks and disasters to the people, society and the state, and among the four types of emergencies[5] , major emergencies and natural disasters are often more hazardous, and this type of emergencies often cause great harm to the human society, so the study of this type of emergencies is also the focus of the current research. Hou[6]'s topic is to discuss the application of blockchain technology in e-government, particularly in the context of China. Promoting the application of blockchain technology in e-government is an important part of this work, which is the first application of blockchain in the Chinese government. There is an abundance of massive relevant data resources, such as meteorological data, urban flooding data, and socio-economic data. It involves big data ontology technology, data fusion methods, data dimensionality reduction and disaster identification, disaster socio-economic loss assessment, emergency response formation and evaluation, etc.;ZHANG X.[7] , through the above analysis, puts forward suggestions to improve the scientific and technological strategy of China's digital public health emergency management system, including (1) establishing a standardised data epidemic information collection system to dynamically perceive public opinion; (2) building a public health big data centre with unified spatial and temporal

benchmarks to achieve cross-regional and cross-industry data aggregation, fusion and sharing; (3) strengthening artificial intelligence technology for outbreak monitoring, prediction and risk research to improve management accuracy and screening efficiency; (4) developing situational interpretation, optimizing regulatory computing technology, and servicing scientific dispatching for emergency response command; and (5) improving the operational institutional mechanism to ensure normal and safe operation, stability.

2.2 Overview of China's emergency management system

For the current situation of China's emergency management, Wang Q et al. [8] discuss the current research status of China's emergency management construction, the main problems, and the basis for establishing an emergency management system. Based on the combination of blockchain technology and big data, it can be applied to all stages of emergency management to achieve security and prevention. For the emergency management of major sudden-onset natural disasters, safeguarding people's lives and properties is the first priority, and emergency rescue is an extremely important link in the whole process of coping with such emergencies. When a major sudden-onset natural disaster occurs, the first priority is to rescue the affected area. The emergency material reserve plays a crucial role in carrying out emergency rescue work. The response to major sudden-onset disasters is a complex and systematic problem that involves various long-standing issues. These include emergency relief work following a major sudden-onset natural disaster, emergency material reserves, emergency material scheduling, and the correspondence between emergency materials and the needs of affected areas. It is crucial to achieve efficient matching of supply and demand in emergency relief efforts. Rescue needs to achieve efficient supply and demand matching material replenishment, and all the above issues have become urgent problems to be solved in response to such emergencies and emergency rescue.

2.3 Emergency management decision-making

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In the four kinds of emergencies after the occurrence of emergency management in the actual work process, throughout the whole process is through the first-line situation of information collection, judgement, continuous emergency decision-making, feedback, correction, decision-making, until the output of the optimal programme, and ultimately to achieve the emergency management of the emergency and emergency rescue. In the actual response to major emergencies in the process, one of the more central process is the emergency decision-making on the emergency, and large groups of emergency decision-making process, due to the actual situation is extremely complex, and in the actual decision-making process has been the existence of a variety of unfavourable factors affecting the quality of decision-making and decision-making process, how to carry out a scientific, rapid, effective and efficient emergency decision-making under the influence of a variety of unfavourable factors, the output of high-quality emergency programme is the next need to be studied. Emergency

response programme is the next need to study the difficulty and focus of the current academic community, there are many scholars on the major emergencies after the emergency management decision-making research, typical Ma Bin, Ding Wenjie[9] for reservoirs, this object of study often occurs in flood emergencies, based on knowledge mapping of reservoir flood emergency decision-making key technologies to carry out research, the article based on reservoir flood emergencies based on the collaborative filtering algorithm is improved, the improved collaborative filtering algorithm filtering algorithm was improved, and the accuracy and recall of the improved algorithm were significantly improved; the outbreak of 2019 (COVID-19) made people pay more attention to the effectiveness and timeliness of emergency decision-making.Du[10] et al. used interval-valued intuitional hesitant fuzzy sets rather than exact numbers to better characterise the ambiguity and uncertainty of emergencies.Bahmani[11] By investigating the 5 September 2022 earthquake evacuation decisions in the Luding earthquake affected area, he contributes to evacuation and emergency response research. Using this data and following the emergency evacuation decision-making mechanism, Bahmani developed six hierarchical series of logistic regression models.

2.4 Synergy in emergency management

China's government departments are based on the division of functional departments of the sectional system, for government functional departments, through analogy analysis of industrial production in the way of system analysis and the operation of government functions, China's emergency management departmental collaborative decision-making system level analysis, there are many scholars on the departmental collaborative emergency management to carry out a more in-depth study, such as Zhai Jing, Hu Feng[12] for the major emergencies in major emergencies public health events, to construct a collaborative emergency intelligence governance framework based on symbiosis theory, in order to break the relief path of emergency intelligence interaction barriers; Guo Tianyi[13] is to use the resilience mechanism to examine the disaster resilience of basic urban public services, and to continuously improve the five dimensions of organisational resilience, social resilience, market resilience, technological resilience and order resilience, to improve the resilience of basic urban public services to disasters, to improve the resilience of the public services to disasters and to improve the resilience of the public services to disasters. Zou Yunjin[14] and others, under the analytical framework of the collaborative governance contingency model, have targeted the establishment of loosely coupled collaborative systems to establish a "full crisis" and "full cycle" collaborative concept, and a resilient "full-cycle" collaborative system. In this paper, we explore the way out of the "all in the same boat" through the use of ATC (Objective Level Transformation), which is a new and resilient way of collaborative governance for the "whole society". In this paper, by using the ATC (Aim Cascade Method) to divide the national functional departments from the perspective of the authority to carry out the hierarchical division, through the division of government departments in the process of emergency management functions, the whole country's emergency management functions of the main departments are divided. First of all, the whole national level emergency management system is divided into a large system, for this large system, the use of industrial engineering, systems engineering ideas based on the system of emergency management departments for the division of functions of the department, and divided into three levels, and then the three-tiered system for the optimisation of the system cascade study, which can be used to carry out the work of the inter-departmental cascade, the feedback relationship between the coupling in order to

achieve the The overall departmental collaboration and emergency management decision-making and emergency rescue effect is optimal.

3 Emergency Response to Major Emergencies and Collaborative Decision-Making by Sectors under Digital Intelligence Technology

3.1 Full-cycle prevention and control of emergency management for major emergencies

In the whole process of emergency management response to major emergencies and unconventional events, often involving many aspects, in order to better respond to such emergencies in the actual process, it is necessary to analyse the whole process of emergencies (Figure 1). Firstly, the first stage, this paper divides the whole process of the whole emergency into four stages - "before the emergency", "during the emergency", "after the emergency", "learning feedback". Firstly, in the stage of monitoring and early warning of emergencies and preventive preparations, it is necessary to establish databases and conduct relevant simulations for the four types of emergencies. This preliminary work is crucial for predicting and preventing the occurrence of emergencies. In the second stage, it is necessary to carry out emergency response and rescue operations in the event of emergencies. In this process, it is necessary to quickly collect emergency intelligence and formulate corresponding emergency decision-making programmes based on the acquired front-line emergency intelligence. In order to achieve this goal, the need to do a lot of preparatory work, including a large number of reserves of emergency supplies, and the entire emergency management process in the event of emergencies in the emergency management process needs to be achieved should be in charge of departmental decision-making, only to achieve efficient collaboration between the departments, so that in the event of emergencies in a limited period of time to carry out efficient, scientific emergency decision-making quickly, effective emergency rescue; the third stage is the emergency incident After the occurrence of the incident, even though the rescue work in this stage has come to an end, it is also very important for the post-disaster emergency recovery and the recovery of the relevant areas of civil construction and people's livelihood, which not only needs to pay attention to the current impact of the incident, but also needs to consider its long-term social and economic impact. There is a need to accurately assess the extent of damage, rationally allocate resources and formulate feasible plans to ensure the long-term stability and development of the affected areas. At this stage, it is still important to keep an eye on the disaster situation in the affected areas to avoid secondary hazards caused by derivative and secondary disasters. At the same time, the monitoring of public opinion on the Internet should not be neglected. In an information-based society, online public opinion can often sway public opinion and affect social stability. Therefore, a timely and effective public opinion monitoring mechanism is needed to prevent and respond to possible negative public opinion. Finally, every emergency management response requires learning and summarising each emergency incident, reviewing the incident, learning lessons from the incident and feeding back into the next emergency response. This reflection and learning mechanism is essential to improving emergency management capabilities.

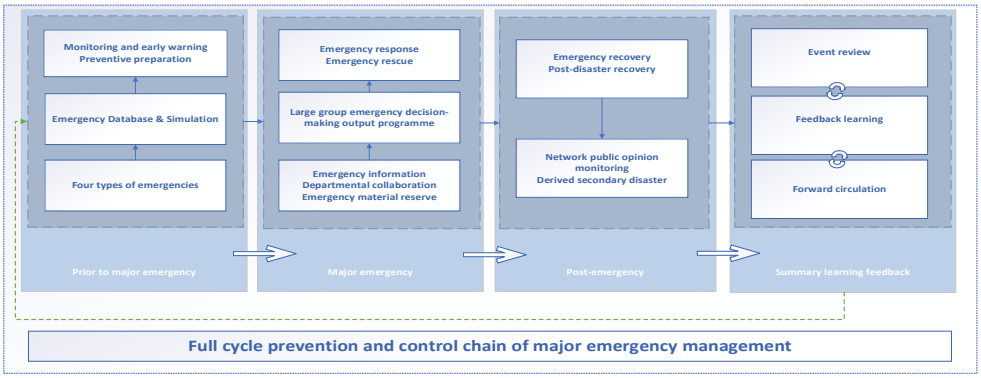

Fig. 1. Full-cycle chain of defence and control for emergency management of major emergencies

3.2 National Security Emergency Management - Sectoral Cascade Structure in a Three-Tier System

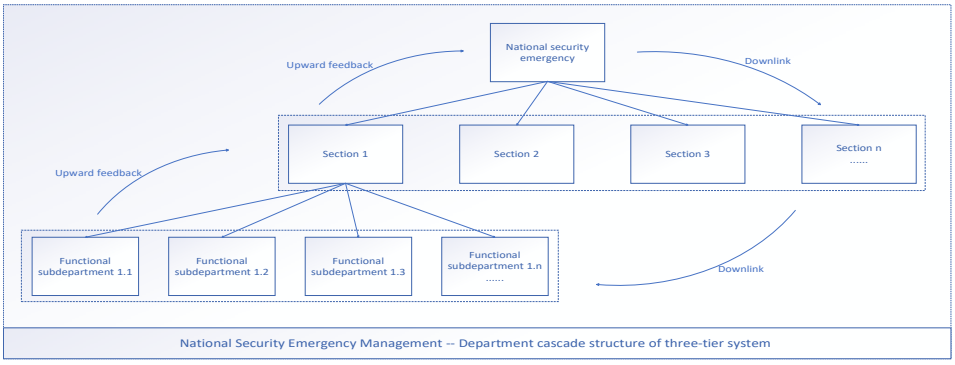

Fig. 2. National Security Emergency Management - Sectoral Cascade Structure of the Three-Tier System

The country is an ultra-complex system composed of a number of functional departments, and the division of functions and powers makes the system operate in an orderly manner, which drives the whole country forward. In the context of the overall national security concept, in order to further improve the capacity of China's emergency management, now using the theory of hypercyclic[15]-[16] the entire national system for the splitting of functions, the national emergency management system is split as (Figure 2). As can be seen from the figure, the whole national emergency management is divided into three tiers. The first tier is the framework of the larger national security emergency response, the second tier consists of a number of parallel related functional departments, and the third tier consists of sub-functional departments of each functional department. This sectoral cascade structure suggests that there is a top-down cascade of decision-making and a bottom-up upward feedback process in conducting emergency management. In this hierarchical structure, the overall optimal solution of the large system can be carried out by using the idea of objective cascade (ATC)[17]-[18] . In the process of this hierarchical structure, departmental decision-making is not done independently, but communication and collaboration between departments, which helps to realise the wholeness and coordination of the whole country's emergency management. This

top-down and bottom-up two-way communication mechanism is crucial in the emergency management process. It ensures the flow of information between all levels, while guaranteeing the implementation of decisions. In this way, the state is able to respond quickly to emergencies and achieve optimal allocation of resources. In addition, this sectoral cascade structure helps to strengthen the synergy between different functional departments. As each functional department has specific responsibilities and tasks in emergency management, this structure enables them to quickly coordinate their actions and jointly respond to challenges during emergencies. In this way, the State is able to minimise disaster losses, safeguard people's lives and property and the stable development of society, and restore normal order as soon as possible.

3.3 Digital Information Technology-Supply and Demand Matching Architecture for Emergency Supplies (Security)

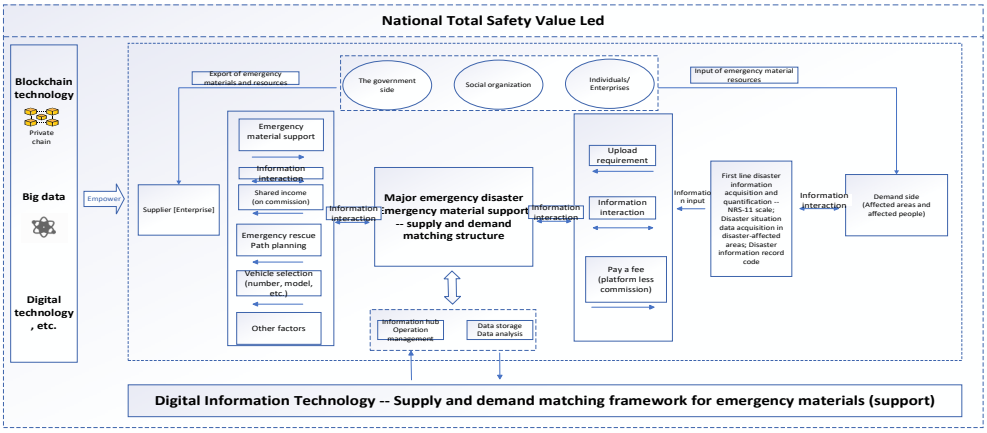

Fig. 3. Digital Information Technology - Supply and Demand Matching Architecture for Emergency Supplies (Safeguards)

After the occurrence of a major sudden-onset natural disaster, the most central task is to carry out emergency rescue quickly and efficiently, and the most central part of the emergency rescue is to achieve adequate emergency material protection and supply replenishment to the affected area. In order to achieve adequate material protection and continuous supply of materials in the limited time during the sudden-onset event, a set of scientific and effective emergency material supply-demand matching architecture is needed to achieve technical support for the demand (Fig. 3), which shows the research on supply-demand matching architecture based on digital technology. Figure 3 shows the research on the supply and demand matching architecture of emergency material security based on digital technology, which is centred on solving the problem of emergency material security after the occurrence of major sudden natural disasters. Under the guidance of the overall national security concept, the supply/demand matching architecture is jointly constructed by three main bodies, namely the governmental party, social organisations and individuals or enterprises, which can act as both the exporter and the importer of emergency material resources, in order to ensure the continuous input/output of material sources. Now, a supply and demand matching architecture is constructed for the emergency material security after an emergency event in a certain region

and the matching of supply and demand between the affected region and the emergency material reserve place. The architecture consists of the demand side of the affected region, the provider of emergency supplies and the platform. The demand side inputs frontline information into the platform, including uploading demands, conducting information interactions, and uploading demands. All of this information is collected into the platform. The provider of emergency supplies is responsible for delivering relevant information such as emergency supplies guarantee, emergency rescue and route planning to the platform. The platform is based on blockchain technology and big data and other digital technologies for support when scheduling and matching materials, so as to realise efficient and scientific emergency material guarantee and accurate supply and demand matching. In order to improve the process and quality of emergency decision-making, the key step on the demand side is to obtain frontline information material on the disaster situation. Relevant emergency management professionals need to go to the affected area to obtain corresponding information data after an emergency, and combine quantitative research methods (e.g., NRS-11 scale) and disaster information record codes to obtain frontline information and then realise information input. In this platform, the dispatching and matching of supplies is carried out in an efficient and scientific manner. The use of digital technologies, such as blockchain technology and big data, makes the matching of supply and demand more accurate and faster, shortening the time for emergency decision-making and improving the quality of decision-making. At the same time, the platform also provides a more convenient and efficient way for the government, social organisations and individuals or enterprises to work together, and promotes collaboration and cooperation between multiple parties.

3.4 Framework for a coordinated sectoral response mechanism for emergency management in major emergencies

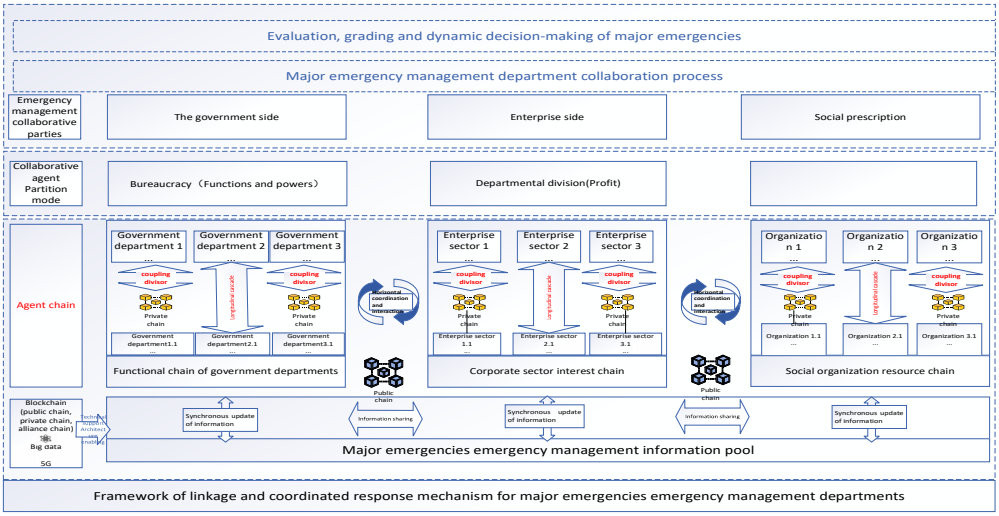

Fig. 4. Framework for a coordinated response mechanism for major emergency management sectoral linkages

In the previous section, the whole process of major natural disasters and the matching of supply and demand of materials were studied, and this paragraph further explains the collaboration between the main departments of emergency management using the hypercyclic theory combined with the three-tier structure of the state (Fig. 4), which is a systematic division of the whole emergency management process based on the use of the hypercyclic theory and the idea of target level method, and supported by digital technology to achieve an efficient departmental Collaborative decision-making process. The process clearly divides the whole emergency management subject sector into three emergency management collaborative subject parties, which are the government party, the enterprise party and the social party.

This division of subject parties corresponds to the division of sectional departments and the division of social organisations. Specifically, the subject chain of the government side realises organic linkage and collaborative decision-making between departments through the use of the private chain in the blockchain; while the horizontal linkage between the government and enterprises and social parties is realised through the public chain in the blockchain. With the help of blockchain technology and its unique technical advantages, mutually beneficial sharing and effective communication of decision-making information can be realised, so as to improve the quality of decision-making intelligence information and thus enhance the quality of emergency decision-making. In addition, the information pool of major emergencies emergency management further improves the quality of decision-making by achieving synchronous updating and sharing of information. In conclusion, the study of the whole framework of the linkage and coordinated response mechanism of the emergency management departments of major emergencies shows that, in the process of emergency management, since emergencies are in the process of constant dynamic change, the whole decision-making process also needs to be adjusted in a timely manner and multiple rounds of decision-making are carried out. This requires repeated iterations and optimisation of the above process to ultimately achieve the entire emergency response. In order to better respond to major emergencies, emergency management authorities need to continuously strengthen information sharing and collaborative linkages. The use of blockchain technology can also effectively prevent information leakage and tampering, ensuring information security in the emergency response process. At the same time, through the decentralised characteristics of blockchain technology, it can avoid the interruption of information transmission due to the failure of the central node and ensure the continuity and stability of emergency response. In addition to blockchain technology, emergency management departments can also make use of big data, artificial intelligence and other advanced technologies to make more accurate predictions and analyses of emergencies, and improve the scientific and targeted nature of decision-making. At the same time, collaboration and information sharing with other departments will be strengthened to form a cross-departmental and cross-field collaborative emergency response mechanism to jointly deal with major emergencies. In the process of emergency management, emergency management departments also need to focus on communication and interaction with the public, strengthen social mobilisation and publicity and education, and improve the public's awareness of emergency response and self-help ability. Through the establishment of a scientific and perfect emergency management system and the strengthening of information disclosure and transparency, the public's trust and support can be better gained, and social stability and security can be jointly maintained. In conclusion, strengthening information sharing and collaborative linkage is the key to responding to major emergencies. Under the evolving technological conditions, emergency management authorities need to actively

explore and innovate to continuously improve the capacity and level of emergency response and make greater contributions to safeguarding people's lives and property and maintaining social stability.

3.5 Sectoral Cascade of Major Emergency Management & Participant Linkage and Coordination Mechanism Structure

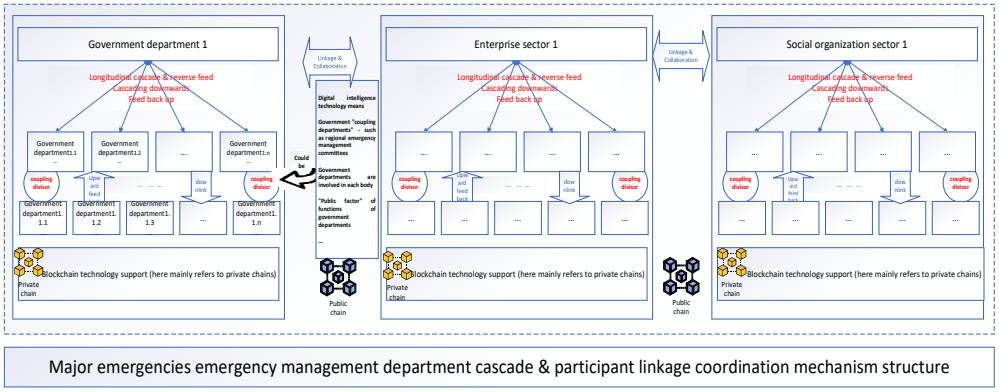

Fig. 5. Major Emergency Response Management Sectoral Cascade & Participants' Linkage and Collaboration Mechanism Structure

This section (Fig. 5) further elaborates and explores the framework of the major emergency management sectoral coupling and response mechanism from the previous section. Firstly, the overall collaborative decision-making of government departments is subdivided, revealing the centrality of the downward cascade as well as the upward feedback information transmission process, and the most crucial factor is the coupling factor (explained below), which usually refers to the various subjects involved in the collaborative decision-making of government departments, such as the jurisdictional emergency management committees, which are the public factors for realising the functions for adjusting the collaborative decision-making between departments in order to achieve optimal decision-making. In order to achieve this goal, it is necessary to use advanced digital technologies, such as the use of private chain (private chain in blockchain) as a technical support. Similarly, for the whole horizontal coordination process among the three subjects, the public chain in the blockchain is also needed to achieve the optimal overall emergency decision-making. This is a study of the technical framework of the linkage between the emergency management departments and the participants of major emergencies. This linkage response mechanism framework not only solves the communication barriers between departments, but also better integrates resources and forms the synergy of emergency response. At the same time, the combination of private chain and public chain ensures the security and transparency of data, which makes the decision-making more scientific and reasonable. In the face of major emergencies, emergency management authorities can respond quickly and collaborate efficiently to jointly meet the challenges. The application of this linkage and coordination response mechanism framework not only improves the efficiency of emergency response, but also reduces the cost of emergency response and better protects the lives and properties of the people.

4 Conclusions

4.1 Conclusions

This paper first examines the evolution of China's emergency management in a comprehensive and full-cycle manner, before proposing improvements to address shortcomings. Then, using hypercyclic theory and the concept of target cascade, we divide emergency management functions into different levels, providing a theoretical foundation for future research. Furthermore, this paper conducts extensive research and analysis on the central issue of emergencies - the material security of emergency rescue and the matching of material supply and demand. To that end, we have developed a set of detailed frameworks for matching the supply and demand for emergency materials (safeguards), which provides strong support for the emergency rescue of natural disasters. Finally, based on the theoretical foundation of the previous paper, this paper combines digital intelligence technology to further analyze and illustrate the synergistic cooperation between the subject departments of China's emergency management, departmental synergy, and emergency decision-making mechanism. On this foundation, we have built a set of national emergency grand frameworks that lay the groundwork for the implementation of an effective emergency management system. To improve the efficiency and effectiveness of the emergency management system even further, we must constantly optimize and improve the existing emergency framework. This includes clarifying and standardizing the responsibilities of emergency management functional departments, strengthening information sharing and synergistic cooperation among departments, and scientifying and standardizing the emergency decision-making process.

4.2 Future prospects

In the future, as technology advances and its applications become more sophisticated, this framework of linked and coordinated response mechanisms will be optimized and improved. We believe that by working together, we can create a more efficient, transparent, and safe emergency management system, as well as contribute more to social harmony and stability. This linked and coordinated response mechanism framework can also be applied to other areas, such as urban management and environmental protection. We can better solve various complex problems and improve the level and quality of public services by collaborating across departments. Simultaneously, we must strengthen our ability to stockpile and supply emergency supplies so that when an emergency occurs, we can provide the necessary emergency supplies in a timely and accurate manner. This necessitates the establishment of a comprehensive emergency supplies reserve system, as well as the effective management and monitoring of emergency supply production, procurement, transportation, and distribution.

Furthermore, we must improve our capacity for risk assessment and early warning of emergencies, as well as crisis management and recovery. This necessitates the development of effective risk assessment and early warning mechanisms, as well as crisis management and recovery mechanisms. Furthermore, this framework of linked and collaborative response mechanisms has the potential to promote innovation and reform in a variety of sectors. In order to better solve problems when responding to major emergencies, various sectors must constantly explore new methods and ideas. Such innovation and reform can not only improve sector resilience, but also provide new impetus to society's long-term development. Finally,

this framework of linked and coordinated response mechanisms has significant practical implications as well as long-term development value. We should continue to investigate and improve it in order to contribute to societal harmony and stability, as well as the improvement of public services.

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