

Article

A Case Study of the “7-20” Extreme Rainfall and Flooding Event in Zhengzhou, Henan Province, China from the Perspective of Fragmentation

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Abstract: Disaster crisis management is the last defensive line in the face of extreme rainstorm disasters. However, fragmentation undermines the effectiveness of disaster crisis management, and the “7-20” extreme rainfall flooding disaster in Zhengzhou, Henan province, China in 2021 revealed a series of fragmentation problems. The effectiveness of China’s emergency storm flooding management must be seriously considered. We used the “7-20” extreme rainfall event in Zhengzhou, Henan province in China as a case study to perform an inductive, qualitative investigation to understand what fragmentation is and how fragmentation reduces efficacy. Most of the data used for this research were gathered from Chinese official records and online news articles. This study first highlights pertinent studies that have been performed and then presents a comprehensive theoretical framework of fragmentation in catastrophe crisis management, which consists of five aspects: fragmented emergency legislation, emergency organization, information, perception, and services. Second, we have deduced which human responses in the “7-20” event represent the fragmentation issues, and we have examined the detrimental effects of fragmentation in flood crisis management. Finally, suggestions are made for China to increase the effectiveness of disaster crisis management, including encouraging regulatory convergence, matching emergency responsibility and authority, establishing an information-sharing platform, bolstering emergency education and raising risk perception, and changing the dualistic system in disaster crisis management.



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Keywords: fragmentation in disaster crisis management; disaster crisis management effectiveness; the “7-20” extreme rainfall event in Zhengzhou; disaster management; China

1. Introduction

The world is now entering the era of “risk society” and “Anthropocene”: the probability of emergencies has increased greatly, and more and more countries are concerned about the potential threat of crises and disasters [1]. Effective and timely disaster crisis management can mitigate damage to people, communities, infrastructure, and the environment, and there is an urgent need to improve disaster crisis management capabilities. However, the ubiquitous fragmentation problem in disaster crisis management undermines its effectiveness. This fragmentation is rooted in the division of labor-based hierarchy and generally describes the situation of lacking coordination between various government departments and agencies, as well as decision-making entities involved in disaster crisis management when facing wicked problems, which are cross-administrative levels, cross-sectoral boundary, and cross-policy areas [2]. Fragmentation problems have led to conflicting and offsetting disaster crisis management operations [3], wasteful duplication

of emergency resources, delayed rescue response, and inadequate support for emergency decision-making. Therefore, it is necessary to examine how to optimize disaster crisis management strategies from a fragmentation perspective by using management tools to achieve an integrated model and maximize the effectiveness of disaster crisis management.

Extreme weather events that surpass preparedness criteria and have a greater impact than anticipated provide a challenge to the capability of disaster crisis management in light of global warming and the growing likelihood of extreme weather [4]. On a worldwide scale, China has experienced the most cumulative total flood frequency over the past ten years, and the frequency of heavy precipitation there exhibits an upward tendency [5,6]. While fast-growing urban areas have high population density and high-risk exposure and rural areas have poor flood-proof infrastructures and high vulnerability [7,8], the predicted economic losses and damage to communities caused by heavy rainfall and flooding increase [9,10], the Chinese government is thus expected to strengthen its capacity for disaster crisis management in the event of major rainfall catastrophes.

Most of the current research on rainfall and flooding management focuses on flood modeling analyses, such as the use of big data and optimal algorithms to provide decision support for emergency escape routes and emergency infrastructure siting [11,12], the potential of unmanned aerial systems for emergency information collection [13], and the technology of two-dimensional hydrodynamic modeling for stimulating flood behavior and predicting inundation depths and areas [14–16]. These studies show the potential of state-of-the-art technological research to be theoretically applied for improving emergency decision support systems. Emerging socio-hydrological research focuses on the interrelationship between social systems and hydrological systems, with particular attention paid to the factors influencing government and household perceptions of flood risk and their impact on disaster crisis management [17–20]. However, there is a lack of empirical research on social systems, especially governmental disaster crisis management capacities, so the next step should be to focus on how to put risk mitigation into practice and analyze how to optimize disaster crisis management, increasing its efficacy in light of governmental administration of reliable emergency methods, institutional structures, and legal frameworks.

The disaster crisis management of extreme rainfall involves various government departments and agencies, administrative levels, and decision-making entities. The number of emergency response entities is large, and the lack of coordination mechanisms makes the fragmentation problem obvious.

In July 2021, the city of Zhengzhou in China's Henan Province, a relatively dry inland city in northern China, experienced extreme rainfall (called the “7-20” event), which inevitably caused damage by exceeding the rainfall standards, but the failure of disaster crisis management artificially led to avoidable deaths and injuries. The problem of fragmented disaster crisis management is prevalent in the emergency operations of decision-making entities. The research question in this paper is: How does fragmentation profoundly affect the effectiveness of disaster crisis management in Henan's rainstorm disaster? Fragmented management led to fragmented rescue responses, such as a lack of collaboration and information sharing among emergency response entities, which further caused conflicting and offsetting actions, missing the golden time for prevention and pre-control, and so on. In this paper, we will identify the dimension of fragmentation shown in the “7-20” event and analyze its negative impact.

The following logical structure was created in this study to address the problems raised above (Figure 1). This article examines the fragmentation in disaster crisis management in this catastrophe and the detrimental effects it resulted in using the case of the “7-20” excessive rainfall event in Zhengzhou, Henan Province, as a case study. Firstly, this paper uses an inductive approach to propose a systematic and universal theoretical framework of fragmentation in disaster crisis management based on the analysis of previously conducted research on fragmentation. Secondly, this framework is then used to analyze the fragmentation and negative consequences of disaster crisis management in the “7-20”

case from a deductive approach. Finally, recommendations are provided for government practitioners and emergency decision-makers to integrate fragmented dimensions and improve the efficiency and effectiveness of disaster crisis management in China.

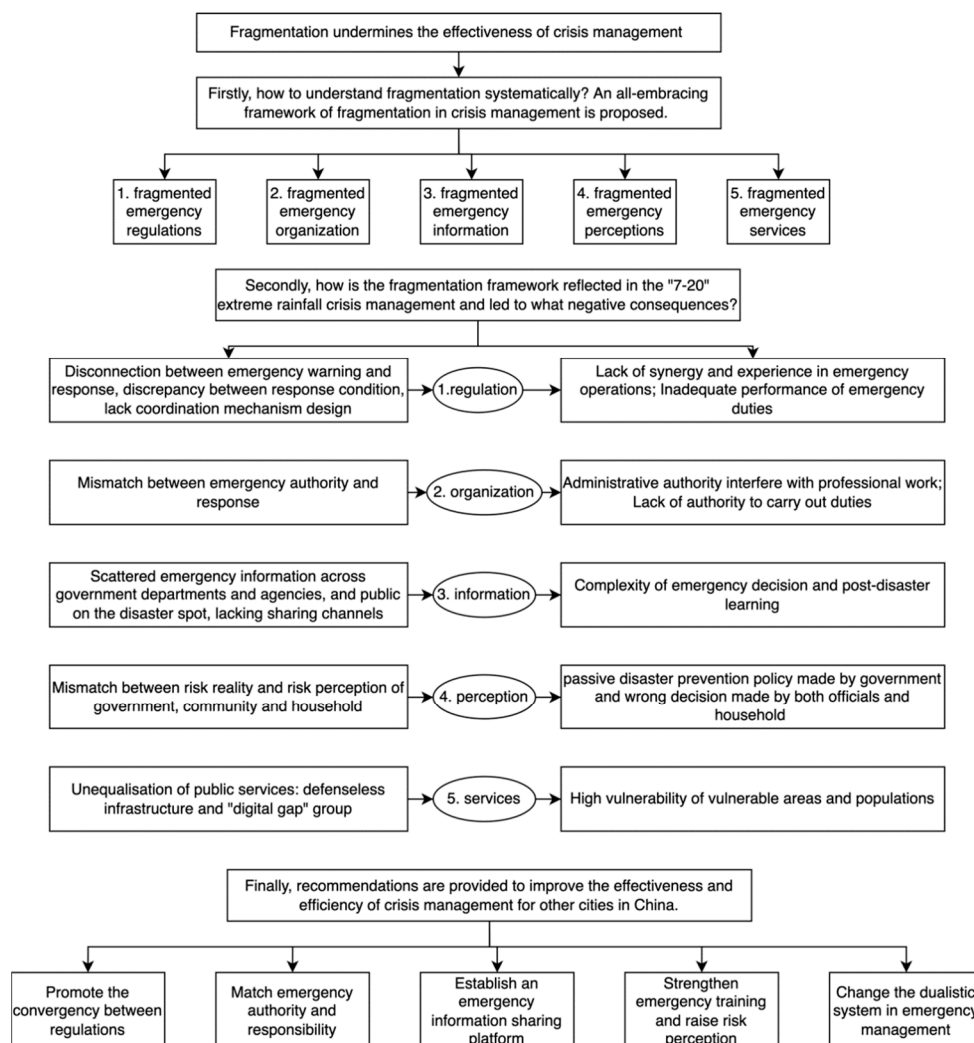


Figure 1. The logical framework of this paper.

The theoretical framework of fragmentation in disaster crisis management proposed in this paper is all-embracing and adds value for conducted fragmentation-related studies. Aside from application in rainfall disasters, the framework is transferable to the analysis of other emergencies. In addition, this paper supplements the empirical research on disaster crisis management of extreme rainfall disasters from the perspective of government management, providing lessons for other cities in China.

2. Literature Review on Fragmentation

Fragmentation is an institutional problem that affects the effectiveness of government [2]. Western scholars' reflections on the shortcomings of New Public Management (NPM) reforms have brought fragmentation research to a climax. By focusing on performance management and single-purpose organizations, NPM ignores the problem of horizontal coordination and may have produced too much fragmentation, hence hampering efficiency and effectiveness [21]. It has been argued that fragmented governments are formed when different departments work in isolation, lacking communication and coordination when faced with a common social problem, which finally leads to the failure to achieve overall policy goals [3]. The polar position of fragmentation is defined as the

situation in which policies which undermine each other can be eliminated, better use can be made of scarce resources, synergies may be created through the bringing together of different key stakeholders in a particular policy field, and citizens can receive seamless rather than fragmented access to a set of related services [22]. Studies have examined the manifestations, causes, and governance measures of fragmentation, suggesting that government fragmentation is manifested by structural devolution, i.e., excessive division of labor leading to a large number of agencies, and excessive separation of powers leading to a loss of central authority to intervene. For instance, fire services, transportation agencies, emergency management departments, hospitals, etc. are typically involved in crisis management in emergencies such as fires, explosions, floods, etc. According to their tasks, various departments are involved in crisis management. This division of labor results in mutual ignorance and hinders coordination and communication between organizations [21]. Blurred boundaries of responsibility and performance management systems that encourage competition rather than collaboration are the reasons for the hindrance of departmental collaboration. According to Chen Kelin, China had a significant epidemic spread in the first half of 2020 as a result of local governments' lack of incentives to work together to avoid disease in the context of their rivalry. Local governments did, however, quickly collaborate after the central government got involved [1,22–24]. Solutions include structural reorganization, hierarchical coordination, i.e., pressure from senior leadership on sectoral agencies to break down organizational boundaries to coordinate [21]; creating an institutional environment and resources that support collaboration [22,24]; and focusing on synergistic goals as much as departmental goals [25].

Disaster crisis management continues the logic of fragmentation, and the problem of fragmentation has become more pronounced as the uncertainty and complexity of emergencies have increased significantly and conventional administrative systems have become ineffective in emergencies. Related studies have enriched the connotation of fragmentation in disaster crisis management, expanding from the shortcomings of collaboration within government to the lack of collaboration in the governance networks between government, society, and the market. Many scholars have discussed the government-dominated character of emergency management in China, arguing against the lack of roles for social organizations and the public in emergency management. In addition, the fragmentation of emergency information and facilities refers to the lack of sharing mechanisms [26–30], for an illustrative example, emergency rescue forces are built according to the type of disaster and there is a lack of cooperation between rescue teams [31]. Among emergency decision-making entities, there is a lack of a holistic picture of danger [32–34]. There is also fragmentation in the emergency process, such as a mismatch between rescue reaction and warning [35–37]. Chinese scholars have investigated the deficiency of Emergency Contingency Plans (ECPs), which are the core emergency guidelines for every administrative level, department, and agency in China, suggesting the implementation of ECPs is defective for the lack of rehearsals, risk assessments, and practical responsibility arrangements, resulting in poor operability [38].

While conducted research has provided a more comprehensive analytical perspective for understanding the issue of fragmentation in disaster crisis management, most of the current research has remained at the stage of analogical research, with conclusions being repetitive and biased depending on the purpose of the research and the individual's knowledge structure, and generally lacking in theoretical research to systematically understand fragmentation, and in practical gains for research progress. Therefore, based on the analysis of existing perspectives, this paper aims to propose a systematic and all-embracing theoretical framework of fragmentation in disaster crisis management from the perspective of management and organizational disciplines, which is applicable to analyze most of the fragmentation in disaster crisis management fragmentation, in the hope of adding theoretical gains to fragmentation research.

3. The Theoretical Framework of Fragmentation in Disaster Crisis Management

3.1. Components and Interrelationships of Fragmentation in Disaster Crisis Management

Fragmentation in disaster crisis management refers to a situation in which the mechanisms, institutions, and legal frameworks for disaster crisis management are not systematic, the emergency decision-maker's perception and operations are not holistic, and there is an unequal supply of emergency services, all of which ultimately prevents the overall objective from being met. According to the definition, this paper argues that fragmentation in disaster crisis management consists of five aspects: fragmented emergency regulations, fragmented emergency organization, fragmented emergency information, fragmented emergency perception, and fragmented emergency services.

This paper argues that the organizational environment, rather than individual characteristics, determines organizational behavior, and that the organizational environment mainly includes regulations and organization. Therefore, organizational and institutional fragmentation is the root cause of the fragmented emergency information and services, for example, the fragmented emergency information is formed due to various departments holding scattered information as a result of organizational sectionalization, and the weak participation of other subjects, such as communities and markets in emergency management, may derive from the monolithic governance of China's government, which led to the lack of collaboration between subjects. Meanwhile, fragmented emergency perception is a cultural environment subtly affecting government, society, community, and individuals, whose formation is related to historical tradition and path dependence, not determined by institutional and organizational factors. However, the integration of emergency perception can be promoted through management tools such as proactive emergency education policies, as emergency decision-makers at many levels, from government officials to families, will be impacted by perception. While institutional and organizational systems can determine the behaviors of an organization, the public perception from the cultural dimension has an incalculable influence on social behaviors.

3.2. Fragmented Emergency Regulations

The emergency regulation system is the basis and guideline for the organization to decide what to do when emergencies erupt. China's emergency regulation system mainly includes emergency laws, management rules, and Emergency Contingency Plans (ECPs), which provide the responsibility arrangements and coordination mechanisms for governmental response to various types of natural and social crises. The fragmented emergency regulations include the following situations: (1) The incoherence of internal logic of the emergency regulations, i.e., goal A is defined but not supported by the correct means. (2) The disconnections of the work process shaped by emergency regulations. Theoretically, policies and institutions must operate through a process of formulation, rehearsal or experimentation, implementation, and evaluation. The absence of any link in the process results in fragmentation. (3) The missing part of crucial arrangements such as practical responsibility lists, and collaboration mechanisms to support integrated emergency response. (4) The lack of articulation in terms of emergency response standards and conditions.

3.3. Fragmented Emergency Organization

The arrangement of authority and responsibility of disaster crisis management form the organization, which defines "who is responsible for what emergency response" and "who oversees emergency authority". The fragmented emergency organization includes the following situations: (1) Excessive distribution of emergency responsibilities led to a fragmented number of departments. (2) Multiple leaders oversee emergency authority resulting in conflicting decisions. (3) Mismatched emergency authority and responsibility led to the inability of some departments or hierarchies to carry out their due duties in a holistic manner and to accomplish overall objectives.

3.4. Fragmented Emergency Information

Fragmented emergency information refers to the lack of overall information on emergencies. The causes of it include both management deficiency, i.e., lack of information-sharing mechanisms between government, enterprises, and the public on the disaster spot who have access to disaster information, and the complexity of collecting real-time crisis information and predicting the crisis trends, which makes it difficult to obtain the overall information.

3.5. Fragmented Emergency Perception

Fragmented emergency perception refers to the different interpretations of the importance of disaster crisis management and the urgency of emergencies by decision-making entities such as government officials and household individuals, in addition to the mismatch between risk perception and risk reality. Emergency perception influences the decisions and actions of emergency subjects, for example, a disaster prevention-active government will pursue proactive mitigation policies, while disaster-aware rational households (individuals) will take the initiative to avoid risks and cooperate with pre-disaster relocation, etc. Factors such as disaster experience, level of emergency education, and socio-demographic characteristics are closely related to emergency perception status [18]. Some studies have shown that government and household mitigation actions significantly influence flood risk and vulnerability trends [19], so it is important to study the fragmentation of emergency perception.

3.6. Fragmented Emergency Services

Fragmented emergency services are reflected in the unequal quality and quantity of emergency services received by different regions and groups. This paper regards disaster crisis management as a type of public service provided by the government, the market, the third sector, and the communities. While the goal of realizing equalization in public services is widely acknowledged by China's government, disaster crisis management service is far away from equalization as this paper points out, for example, rural areas have received less disaster crisis management services than urban areas in China, as most of the emergency resources are gathered in cities. This kind of relationship between rural and urban is also transferable to other dualistic counterparts such as capital cities and non-capital cities, middle-aged groups and childhood and elder groups.

4. Methodology

4.1. Case Study

From 17 to 23 July 2021, Henan Province was hit by a historically extreme rainstorm, which was long-lasting and extensive. The worst-hit areas of this disaster event were the Zhengzhou metropolitan area and the northern part of Henan Province [39]. The cumulative process rainfall in Zhengzhou was 543 mm, with a maximum process point rainfall of 993.1 mm and 24-h precipitation of 552.5 mm, exceeding 80% of the local annual precipitation. The highest rainfall amount reached 201.9 mm at 16–17 h, and this round of rainfall amounted to nearly 4 billion m³ of water, which is the widest range and strongest rainstorm in the history of meteorological observation in Zhengzhou. The waterlogging situation in the urban areas of Zhengzhou was severe, with most areas (479.0 km², accounting for 45.3% of the total area) having a maximum inundation depth exceeding the requirements for urban flood control (0.25 m), and some areas (116.0 km²) even having a maximum inundation depth of 2.00 m or more, with an area of 272.4 km², or 25.8%, having an inundation depth of 0.50 to 2.00 m [16]. The city's 2607 underground spaces and important facilities were flooded, several areas were cut off from water, electricity, and the Internet, and communication and access facilities were damaged. The extreme rainstorm event caused 14,786,000 people to be affected in 150 counties (cities and districts) across Henan Province, with 398 people killed and missing because of the disaster,

of which in Zhengzhou accounted for 95.5% of the number; the direct economic loss was 120.06 billion yuan.

The storm disaster exceeded the preparedness standards and impact expectations, but the fragmentation problems in disaster crisis management in Zhengzhou worsened disaster losses. At 21:59 on 19 July, the Zhengzhou Meteorological Department issued a red warning signal representing the highest level of heavy rainfall disaster, and a second red warning signal was issued at 06:00 on 20 July, but Zhengzhou City's Flood Control and Drought Relief Headquarters (FCDRHs), which is the commanding authority in Zhengzhou city, did not activate the highest-level emergency response as required. During the period from 10:30 to 18:00 on 20 July, the Changzhuang Reservoir experienced a dangerous situation of pipe surge, flooding eruption, and serious waterlogging in the Jingguang Expressway North Tunnel and Zhengzhou Metro Line 5 Train occurred, with most of the casualties concentrated in this period; on the 21st, the Guojiazui Reservoir was flooded due to the occupied floodway. Inadequate emergency actions by the relevant authorities during this period led to tragedies that could have been avoided.

Reflecting on the failed disaster crisis management behind this extreme rainstorm, the issue of fragmentation has surfaced. The division of jurisdiction among several departments and a lack of coordination are both significant contributors to the fragmentation of urban flood control emergency management. The general command of flood control and drought control at all levels should be fully utilized, and the system of forecasting, warning, and planning should be improved. The emergency administrative department should take the initiative to establish and improve the inter-departmental coordination mechanism of urban flood control. Using the "7-20" event as a case study, this paper analyses the reflections and negative consequences of fragmentation in this extreme rainfall disaster crisis management.

4.2. Data Collection

The data for this paper were collected mainly from Chinese government documents and online news reports, including the "Investigation Report on the "7-20" Extreme Rainfall Event in Zhengzhou, Henan Province" issued by the State Council Disaster Investigation Team, and the national-level and municipal-level laws, regulations, and ECPs related to emergency management and flood control. The data collection is mainly from secondary sources, lacking in field research and interviews, and the collectors of secondary data may have reservations or exaggerations due to their preferences, so the data sources are inadequate. This paper will try to select objective data sources and analyze the fragmentation problems of this rainstorm event.

5. Case Study: Introducing a Fragmentation Perspective to Interrogate the Effectiveness of Disaster Crisis Management of the "7-20" Extreme Rainfall Event

5.1. Fragmented Emergency Regulations Led to the Lack of Synergies and Experience in Emergency Operations

5.1.1. Disconnections between Regulations Led to the Lack of Synergies in Response

The flood control disaster crisis management system in Zhengzhou City is cross-boundary, with governments at all levels, different functional departments, and related agencies having to prepare their flood control Emergency Contingency Plans (ECPs) and set the workflow and response conditions within their departments. As a result, many flood-control regulations lack connections with each other, leading to the lack of synergies in response. The following are specific reflections on this case:

- (1) The disconnection between the early warning system and the response system led to a disconnection between the meteorological department's warning actions and those of other departments. The Zhengzhou Meteorological Department issued a total of five red warnings, the highest disaster level, from 21:59 on 19 July until 16:01 on 20 July. Although the Zhengzhou Flood Control Emergency Plan clearly states that receiving a red warning issued by the meteorological department is one of the conditions for

- activating the highest level of emergency response, Zhengzhou City's Flood Control and Drought Relief Headquarter (FCDRH), as the flood control command agency, did not activate the highest-level emergency response as required until 16:30 on the 20th, by which time 18.5 h had passed since the first red warning, and most of the disasters had already occurred, with emergency rescue responses seriously lagging. Besides the FCDRH, functional departments such as the Zhengzhou Transport Department, the district and county governments, and government agencies such as the Zhengzhou Metro Enterprise did not respond to the meteorological department's warning signals in a pre-controlled manner. After the FCDRH launched the highest-level emergency response, the Subway Line 5 Train flooded, but the Zhengzhou government and the Metro Enterprise lacked a linkage mechanism, and the Metro Enterprise was late in launching the emergency response, resulting in the underground drowning accident.
- (2) Discrepancies between response conditions led to inconsistent emergency operations. Disaster crisis management entities set different response conditions according to the characteristics of their management targets (Table 1). For example, the condition for Zhengzhou City's FCDRH to activate the highest-level response is "water may accumulate to a depth of more than 50 cm on most sections of major roads and low-lying areas in urban areas, and water may accumulate to a depth of more than 100 cm under most of the overpasses, and the meteorological department has issued a red warning of heavy rain", the Zhengzhou City's Tunnel Maintenance Center should close the tunnel when the water on ordinary roads exceeds 40 cm, and the Metro Enterprise should stop running and evacuate passengers after the water surface has flooded the tracks. The lack of a common standard of conditions to alert all relevant disaster crisis management subjects to prepare at the same time has led to a serious problem of lagging rescue response, lack of synergies, and fragmented emergency operation.

Table 1. Related Emergency Regulations and Its Formulation Subject in "7-20" Extreme Rainfall Event in Zhengzhou, Henan Province.

The Entities Setting Regulations	Document of Related Regulations
National level laws and regulations	Law of the People's Republic of China on Emergency Response, Law of the People's Republic of China on Flood Control, Water Law of the People's Republic of China, Regulations on the Safety Management of Reservoirs and Dams, Interim Provisions on Reporting of Flood Emergencies and Disasters
Provincial-level regulations	Regulations on the Management of Water Resources Projects in Henan Province
Zhengzhou City's FCDRH	Zhengzhou Flood Control and Drought Relief Command Notice on Strengthening Discipline in Flood Control Work, Zhengzhou Flood Control Emergency Contingency Plan, Duties of Members of the Zhengzhou Flood Control and Drought Relief Command
District, county, township-level regulations	Flood Control Emergency Plan and Flash Flood Disaster Prevention Plan of each district, county, and township
Transport Department	Measures for the Organization and Management of Urban Rail Transit Traffic
Urban Management Department	Zhengzhou Urban Flood Control Emergency Plan
Zhengzhou City's Tunnel Maintenance Center	Zhengzhou City Tunnels Integrated Management and Maintenance Centre Flood Prevention and Emergency Plan for 2021
Zhengzhou Metro Enterprise	Rules for the Organization of Traffic (Subway Line 5 train)

5.1.2. Absences of Formulation, Rehearsal, and Assessment of Emergency Contingency Plans

Emergency Contingency Plans (ECPs) are supposed to go through the process of formulation, rehearsal, and assessment, and the absence of any link results in fragmentation. The “7-20” case has reflected a significant fragmentation problem in terms of the absence of the ECPs process. First, the absence of formulation means some disaster crisis management entities do not even prepare their ECPs as required by law, so when the “7-20” extreme rainfall event occurred those subjects had no plan to follow and responded messily or had no response at all. Second, the absence of ECPs’ rehearsal contributed to the poor disaster crisis management experiences of decision-makers, which further caused them to neglect the working procedures set out by ECPs. During the “7-20” rainfall event, many subjects did not take timely and appropriate measures as required by ECPs (Table 2), even though the conditions for activating are clear, resulting in a serious lag in emergency response.

Table 2. The inappropriate and untimely measures of disaster crisis management subjects in the “7-20” case.

Disaster Crisis Management Subjects	Inappropriate and Untimely Measures
Water Department	1. Warning information was not issued to the community as stipulated in the plan, but only sent to the district and county defense committees or relevant departmental units. 2. Failed to collect and report the dangerous situation of Changzhuang Reservoir and Guojiazui Reservoir in a timely manner as required by the Flood Control Emergency Plan.
Urban Management Department	Failure to issue early warning information to the community by the “Flood Control Emergency Plan of Zhengzhou City” and “Urban Flood Control Emergency Plan of Zhengzhou City”, to activate the emergency response of the city’s FCDRH, and to send the early warning information to the members of the Metro enterprise.
Zhengzhou Metro Enterprise	Failure to investigate potential hazards, activate emergency response, and implement a hazard reporting system as required by the plan
Zhengzhou City’s Tunnel Maintenance Center	Failure to implement its ECP which states that “the tunnel should be closed when water exceeds 40 cm on ordinary roads”.
Emergency Management Department	Failure to activate the emergency response in accordance with the “Zhengzhou Flood Control Emergency Plan” Level I response activation conditions “major danger in Jiangang and Changzhuang reservoirs, or dam collapse in small and medium-sized reservoirs in important locations” in the event of a tube surge in Changzhuang reservoir.
Traffic Control Department	Failure to direct traffic jams in the event of obvious traffic jams as specified in the plan
Water administration authorities, reservoir authorities	Failure to take effective measures to stop reservoir encroachment, reduction of reservoir capacity, and other illegal and irregular acts as required.
Districts, cities, and towns (street offices)	Failure to activate flood control, flash flood emergency response, organize evacuation of people, report disaster damage information in accordance with the provisions of the ECPs.

Finally, the absence of assessing the early warning efficiency shaped the action of the Zhengzhou Meteorological Department, which only focused on issuing warning signals, rather than considering how other departments and the public will react to the warning

signals [37]. In this case, the Zhengzhou Meteorological Department issued a red warning signal with only rainfall forecasts and no defense guides for the public, enterprises, and governments. This makes it difficult for the public who has no weather expertise to judge the disaster consequences only according to the rainfall. The fact that people continued to go to work and school and other sectors continued to operate reflects that they did not take the Meteorological Department's red warning seriously or did not know the red warning at all.

5.1.3. The Missing Responsibility Arrangement and Coordination Mechanisms Led to Inadequate Duty Performance

The content of Zhengzhou's flood-control ECPs is fragmented because of the missing responsibility arrangement and coordination mechanism. The State Council requires that local government ECPs should "clarify the responsibility for predicting, warning, alerting, receiving, response, rehabilitating and rebuilding; clarify the leading organization, commanding organization, daily duty organization, collaborating departments, participating units, responsibilities and authority for emergency response in the administrative region", however, Zhengzhou flood-control ECPs only clarified commanding bodies and participating units, and the emergency responsibility arrangement is largely duplicated with regular responsibilities, which is not useful in the face of extreme rainstorm emergencies. Besides, the ECPs did not include enough emergency participating member units, or enough responsibility lists, for example, the ECP designed by Zhengzhou Urban Management Department did not clarify the flood-control responsibility of Metro Enterprise, which was proved to be an important member in the "7-20" case, and the responsibility list of Zhengzhou Transport Department only contains safeguarding emergency transport, without road condition management under rainstorms. In addition, Zhengzhou flood-control ECPs did not clarify practical emergency coordination mechanisms, which cannot guide the emergency subjects to collaborate.

The blurred, incomplete emergency responsibility arrangement for Zhengzhou city's FCDRH contributed to the absence of effective leadership. When the extreme rainfall continued, with some reservoirs surging and areas flooded, most of the leaders went to the disaster site. Some of them were stuck in traffic, and some of them could not acquire the latest disaster information as the communication facilities were damaged by flooding. No one could study the overall disaster situation and collect news from all sides, so the leadership is ineffective.

5.2. Fragmented Emergency Organization: Mismatch between Emergency Authority and Responsibility

The mismatch between emergency authority and responsibility describes a situation in which "Those who should not be in charge are blindly in charge, those who should be in charge have no responsibility, and those who want to be in charge have no authority." In the "7-20" case, the fragmentation of emergency organization is reflected as follows:

- (1) Administrative authority interferes with professional warning efforts. The professionalism of functional departments leads to mutual ignorance, so certain translatable mechanisms are needed for the professional information to be correctly understood by other departments. The graded warning system of the Meteorological Department (blue, yellow, orange, and red, from lowest to highest level) is this kind of translatable mechanism, making it easier for others to understand the severity of rainstorms. However, the meteorological sector suffers from a fragmentation problem of mismatched authority and responsibility, with administrative powers interfering with the performance of professional meteorological duties. To respond to higher-level assessments, the meteorological sector issues around three hundred warnings per year, the vast majority of which are non-essential [40], weakening the credibility of warning signals.
- (2) Important authorities are absent from flood-control responsibility, and managers with responsibility have no authority to carry out duties. In this case, the Guojiazui

Reservoir was at major risk of roiling due to the spillway being blocked by a temporary construction road, and the construction unit, Henan Wujian Construction Group (referred to as Wujian), built a construction road within the spillway in 2018, which seriously affected the safety of the reservoir's flood discharge. In 2021, the Zhengzhou Erqi District Government requested Wujian to restore the spillway to its original state and clean up the abandoned soil and slag before the flood, but Wujian rejected it with the excuse that their construction was not under the control of the district government but the Zhengzhou Municipal government as a key project [41]. The Zhengzhou Municipal Government has the power to manage infrastructure planning but not the responsibility for local flood control. The construction of infrastructure has caused negative flooding effects in the short and long term. Yet, the district government, responsible for local flood control, has no power to interfere with municipal projects. The fragmented emergency organization has resulted in a lack of flood prevention considerations in infrastructure development and the overall goal of building a flood-resilient city cannot be achieved.

5.3. Fragmented Emergency Information Exacerbates the Complexity of Decision-Making and Post-Disaster Learning

Emergency decision-makers are faced with the conflicting emergency ethics of economic operation and safety assurance, and therefore need sufficient information to support emergency decisions, yet the fragmentation of emergency information has led to insufficient support for that. Functional departments have access to information on rain-storm disasters, for example, the meteorological department monitors rainfall, the emergency management department has risk assessment data, and the water resources department monitors water conditions such as water level and flow rate in rivers, lakes, and reservoirs, etc. The lack of information sharing between departments and the fragmentation of information sources exacerbates the complexity of emergency decision-making.

The post-disaster investigation was difficult, complex, and professional, based on the scattered responsibilities of disaster crisis management subjects, the large number of regulations and documents, and the wide scope of the disaster. The State Council Disaster Investigation Team conducted a comprehensive and detailed investigation into the extreme rainfall event in Zhengzhou, Henan Province, and published an investigation report. This is the first region-wide survey of natural disasters in China and is of special significance. The investigation team reviewed more than 90,000 pieces of information, explored the site more than 100 times, conducted nearly 200 discussions and research, and interviewed more than 450 people, which entails a huge workload; and the investigation team was composed of academicians and authoritative experts in various professional fields, and the investigation team was divided into several special working groups according to different investigation themes. The fragmentation of storm emergency information has increased the difficulty of post-disaster investigation and learning.

5.4. Fragmented Emergency Perception Reduces Risk Awareness

The government and the public are prone to underestimate the probability and severity of extreme rainstorms, thus, there is a mismatch between risk reality and risk perception, forming the fragmentation of perception. Perception will further determine decision making, for example, a government with low-risk perception will produce a passive disaster prevention policy, demolishing the environment with no restraint for development until a crisis erupts; the officials with bounded-rational perception may make a wrong judgment about disaster reality and misdirect disaster crisis management; the households and individuals with low awareness about risk may not be inclined to take prevention measures. In the "7-20" case, the Zhengzhou leading officials from the commanding department subjectively judged that the inland northern areas in China will not suffer from rainstorms, even with the red warning signals from the Meteorological Department, which directly led to the lagging emergency response of all sectors. In addition, the public is

reliant on official measures and the majority will continue to work and go to school if the notice for closing classes and business is not issued officially.

5.5. Fragmented Emergency Services Result in the High Vulnerability of Vulnerable Regions and Groups

- (1) Zhengzhou, as the provincial capital city, received extensive public attention and government attention, thus, social donations from celebrities and corporations were tilted towards Zhengzhou, while non-capital cities such as Xinxiang and Hebi in northern Henan suffered relatively more severely from the disaster [39], but received less public attention and had more difficulty in accessing emergency relief resources.
- (2) Compared to urban areas, rural areas are weaker in disaster prevention, mitigation, and relief due to a lack of emergency infrastructure and the isolation of transportation, and the prevalence of low preparedness in rural areas. In the post-disaster recovery segment, there is a large gap between the level of emergency services received by the cities and the villages. In Zhengzhou, urban areas recovered quickly after the storm, with the city functioning normally again, while a rural area in Xinxiang was still muddy four months after the storm, with abandoned vehicles and scouring debris still uncleared.
- (3) Vulnerable groups such as the elderly and the disabled are in weaker physical condition, so they are more dependent on rescue services. Besides, the elderly groups have a large digital gap, so it is difficult for them to receive warning information through the internet and mobile channels.

6. Lessons and Key Points for Improving Disaster Crisis Management in China from the “7-20” Case

6.1. Promoting the Convergency between Regulations

Emergency-related regulations are the guidebook for governments and institutions to take emergency actions in the face of extreme rainfall events. Holistic regulations shape a comprehensive emergency response, while fragmented regulations shape fragmented emergency operations. The fragmentation problem in the “7-20” case provides ideas for emergency practitioners to optimize the emergency regulations system.

Firstly, a warning-led emergency response mechanism should be established, and the commanding department should be synchronized with the warning department to keep disaster information and emergency operations in sync, to prevent the warning department from being siloed from others. Drawing on Beijing’s experiences, in which a holistic emergency regulations system was developed after the 2012 rainstorm, the meteorological department is required to obtain the consent of the commanding authority to issue a warning above the yellow level, thus ensuring that the command authority is kept abreast of rainfall information and keeps in touch with warning actions [42]. In addition, detailed emergency operations of commanding agencies and members corresponding to the warning levels are explicitly formulated to ensure that all functional departments act correctly upon receiving the warning signals. These arrangements are designed to ensure that warning actions are closely linked to the emergency pre-control response operations.

Secondly, the land development department should be incorporated into the flood-control emergency system to achieve whole-process disaster crisis management. Infrastructure and housing construction will change the condition of the city’s subsurface, thus affecting flood production and confluence. Reducing flood risk requires ensuring that infrastructure is built to meet flood resilience requirements. Beijing has set up a special sub-command for housing and urban-rural construction to manage the prevention of storm flooding and geological hazards in housing, transport, rail, and underground space, incorporating land development into the flood-control emergency system to achieve a combination of prevention and rescue.

Thirdly, flood control emergency pre-drills and drills are of great significance. ECPs are the guidelines for emergency rehearsal in China, so they should be strictly implemented, and emergency coordination mechanisms should be explicitly formulated. It is

better to practice it once than talk about it a thousand times. Therefore, the following recommendations for flood control emergency pre-drills are made: first, creating sound material reserves, such as medical supplies and emergency maintenance for daily necessities; second, using big data technology to analyze the best transfer routes and construction locations for emergency facilities; third, for flood-prone areas, developing flood control drills for the active population and key transportation sectors; fourth, to stay up to date on flood disaster information and maintain emergency management operations in sync, collaboration mechanisms should connect various government departments, the public, and other government agencies like city transportation companies.

6.2. Matching the Emergency Responsibility and Authority

The fragmented emergency organization has led to a situation in which those who should not be in charge are blindly in charge, those who should be in charge have no responsibility, and those who want to be in charge have no authority. Matching the flood-control emergency responsibility and authority requires that the departments with responsibilities have sufficient authority and resources to intervene in the irregularities, while at the same time compacting the flood-control responsibility of the authority departments. Besides, it is important to promote the matching of managerial powers with professionalism to reduce the interference of administrative disadvantages in the professional work of flood-control emergency management.

6.3. Establishing the Emergency Information-Sharing Platform

Obtaining holistic flood disaster information can reduce information asymmetry and uncertainty, thus providing scientific support for emergency decision-making. To tackle the problem of fragmented information, firstly, it is necessary to establish a disaster information sharing platform to synchronize information from all sides. For example, the Department of Homeland Security Science and Technology Directorate (DHS-S&T) in the United States has launched the Social Media Alert and Response to Citizen Threats (SMART-C) program using big data technology to collect real-time disaster information from the public at disaster sites, enabling information sharing between the government and the public [43]. Secondly, as the disaster information from the spot is hard to collect due to the flooded transportation and damaged communication facilities, advanced technology can be used to collect real-time information and analyze flood trends. For instance, satellite images, wireless communications, unmanned aerial vehicles, and remote sensing technology will help to recover real-time information on flood threats, assisting in the issuance of early warnings and the gathering of disaster information.

6.4. Strengthening Emergency Education and Raising Risk Perception

The government should strengthen the education of emergency response knowledge for managers of government departments, grassroots government executives, enterprises, and institutions, as well as the public, and do a good job in emergency response publicity and education to raise awareness of the crisis, as well as prevention and response among all parties. For government personnel, it is important to improve their emergency sensitivity and emergency expertise and to take timely emergency action; for the public, it is important to improve their awareness of prevention and their ability to make judgments and to provide emergency self-help training. Besides, the government should announce risk sources to the public.

6.5. Changing the Dualistic System in Disaster Crisis Management

Urban and rural areas, provincial and non-provincial cities, first-tier and non-first-tier cities, middle-aged and non-middle-aged groups, etc. These 'pairs' are strong on one side and weak on the other, forming a dichotomous structure. The binary structure is not only deeply rooted in people's minds but is also hidden in the system to entrench further the dichotomy, such as in the urban-rural hukou system. Emergency services are also

influenced by the dualistic concept and system, which leads to the inequality of services. The strong side of the dualistic structure usually has better access to emergency resources and receives a better level of emergency services than the weak side.

To solve the problem of fragmentation of emergency services, the dualistic concept and system of disaster crisis management should be broken down to equalize emergency services. Previous discussions on the division between urban and rural areas, first-tier cities, and non-first-tier cities have aggravated the recognition of the binary structure in the social consciousness, so it is necessary to break the binary pattern in the construction of the discourse, focus on regional integration, dilute the binary concept from the consciousness, and balance the public attention, to promote the disadvantaged side to receive more emergency resources, especially social donations and government attention. In terms of institutions, the administrative boundaries of emergency services should be broken down and emergency services should be reshaped to focus on the needs of the public; support should be given to the construction of disaster prevention, relief, and mitigation systems and capacities in rural areas, to improve their preparedness.

7. Conclusions

The problem of emergency fragmentation emerges from the failed emergency management in the “7-20” extreme rainfall event in Zhengzhou, Henan Province. This paper takes this as a case study and innovatively uses the theoretical framework of emergency fragmentation to analyze the human response to the “7-20” event, and the following is a summary of the key content:

First, fragmentation in disaster crisis management consists of five aspects: fragmented emergency regulations, fragmented emergency organization, fragmented emergency information, fragmented emergency perception, and fragmented emergency services. Among them, fragmented regulation is the key issue, which both underpins the functioning of the organization and influences other aspects of emergency response fragmentation. This analytical framework of fragmentation is beneficial for the academic community as it fills a gap in the current study of emergency fragmentation and flood disasters and provides theoretical support for the reform of China’s disaster crisis management system, mechanism, and legal system.

Second, the “7-20” case study revealed harmful effects of fragmentation: fragmented emergency organization, or the mismatch between emergency authority and responsibility, contributed to the lack of authority to carry out duties and interference with professional work; fragmented emergency information exacerbates the complexity of decision-making and post-disaster learning; fragmented emergency perception lowers risk awareness; and fragmented emergency regulations led to the lack of synergies and experience in emergency operations. These findings offer emergency management expertise to other Chinese cities, enhancing the human response to storms and floods that occur on a regular basis.

Third, measures for holistic flood-control disaster crisis management include promoting the convergence between regulations, matching the emergency responsibility and authority, establishing the emergency information-sharing platform, strengthening emergency education and raising risk perception, and changing the dualistic system in disaster crisis management. These recommendations will help policymakers encourage the development of an intersectoral, collaborative, and whole-process approach to emergency management, with the hopes of strengthening emergency management capabilities, enhancing the efficiency of disaster responses, and defending lives and property.

This paper discusses the negative impact of the fragmentation of emergency management of heavy rainfall and floods on the effectiveness of emergency management, but is limited by the lack of government information and does not analyze in depth the interaction between the various types of fragmentation and how they are manifested in the presented case. For example, the fragmented emergency regulations and the fragmented emergency organization, although manifested in different ways, affect each other, and an in-depth discussion of the interactions between fragmentation issues would be useful in

proposing more realistic governance measures. In addition, most of the case studies in this paper were sourced from secondary sources and face-to-face interviews could not be conducted with the relevant flood control emergency decision-makers in Zhengzhou, Henan Province, so there is still much case-related emergency management information yet to be explored. Future research will further explore the interrelationships and causes of emergency fragmentation, dig deeper into the information related to the emergency management measures in Zhengzhou, Henan Province, during the “7-20” disaster, and propose more specific policy recommendations to provide a basis for policymakers to reform emergency management mechanisms, institutions, and legal systems.

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